National Defence Défense nationale

DEFENCE RESEARCH AND DEVELOPMENT CANADA (DRDC)
RECHERCHE ET DÉVELOPPEMENT POUR LA DÉFENSE CANADA (RDDC)

Analysis of a methodology to assess barriers to instructional technology adoption

Stephen Downes
Bruno Edmond
National Research Council of Canada (NRC)

Prepared by:
National Research Council of Canada (NRC)
1200 Montreal Road
Ottawa, Ontario K1A 0R6

Memorandum of Understanding: NRC - National Research Council of Canada (NRC) concerning Research, Development, Test and Evaluation, Technical Services and CoOp RD
Technical Authority: Blake C.W. Martin, Defence Scientist
Contractor's Date of Publication: March 2023

Defence Research and Development Canada

Contract Report
DRDC-RDDC-2024-C047
March 2024

Canada

IMPORTANT INFORMATIVE STATEMENTS

This document was reviewed for Controlled Goods by Defence Research and Development Canada using the Schedule to the *Defence Production Act*.

NRC·CNRC

Training and Education Modernization: Analysis of Barriers to Technology Adoption

Date: March 27, 2023
Author(s): Stephen Downes, Bruno Emond

Digital Technologies Research Centre

National Research Council Canada | Conseil national de recherches Canada

Canada

Abstract

This report examines work by DRDC to develop a model of factors that inhibit the use of learning technology in a Canadian Forces Context. The focus is to assess the background and study methodology undertaken by DRDC. It proceeds in three major states: first, a review of the literature related to technology adoption, risk management, and assessment validation; second, an examination of DRDC's pilot study and proposed wider-scale assessment from the perspective of the literature review; and third, a series of recommendations to DRDC based on the first two parts.

A. Background Literature

Acceptance Models

Technology acceptance and diffusion models describe and explain the adoption and deployment of new tools and applications. *Adoption* theory describes the choices individuals make, and is understood in terms of behaviour change. *Diffusion* theory considers the spread of a technology over time across an organization (Straub, 2009, 627).

These models are largely based in social cognitive theory and describe two major roles for social learning: vicarious experience through modelling (Bandura, 1963, 607), and vicarious experience mediated through the use of a technology (Bandura, 2001, 17). Major factors influencing acceptance decisions include: attention to the behaviour, whether it is retained or recollected, whether it can be reproduced successfully, and whether the agent is motivated to do it again (Straub, 2009, 629).

Innovation Diffusion Theory

Rogers' Innovation Diffusion Theory (1962) describes five stages of evaluation of an innovation: awareness of the innovation, persuasion of its benefits, decision to adopt the innovation, implementation of the decision, and confirmation of the innovation process. These happen in individuals at different times, resulting in Rogers' 'innovation diffusion curve', which describes the progress of an innovation through early adopters, mainstream and late adopters or laggards.

Adoption is "a decision to make full use of technology innovation as the best course of action available" where *innovation* is "anything that is perceived as new from the perspective of the adopters and is described by Rogers by five characteristics: relative advantage, compatibility, complexity, traceability, and observability" (Rogers, 1995, 5; Granić, 2023, 184-5). Following Bandura, Rogers also describes the channels of communication through which an innovation is modelled, and the social system, that is, the "a set of interrelated units that are engaged in joint problem-solving to accomplish a common goal" (Rogers, 1995, 23) in which the adoption decision takes place.

Theory of Planned Behavior

"A person's intention to perform (or not to perform) a behaviour is the immediate determinant of that action" (Azjen, 1985, 12). Changes in intention can be caused by changes in the salience of belief, new information, changes in confidence or commitment, individual differences such as skills, willpower, emotions and compulsions, or external factors such as time, opportunity, and dependence on others.

Technology Acceptance Model

Davis' Technology Acceptance Model (TAM) considers attitudes, rather than behavioural intentions, as the main predictors of behaviour. According to the theory, the user's motivation can be explained by perceived ease of use and perceived usefulness (Davis, 1989, 333).

Scale Items		Factor 1 (Usefulness)	Factor 2 (Ease of Use)
Usefulness			
1	Work More Quickly	.91	.01
2	Job Performance	.98	−.03
3	Increase Productivity	.98	−.03
4	Effectiveness	.94	.04
5	Makes Job Easier	.95	−.01
6	Useful	.88	.11
Ease of Use			
1	Easy to Learn	−.20	.97
2	Controllable	.19	.83
3	Clear & Understandable	−.04	.89
4	Flexible	.13	.63
5	Easy to Become Skillful	.07	.91
6	Easy to Use	.09	.91

Figure 1 – Factor Analysis of Perceived Usefulness and Ease of Use. By the authors; adapted from Davis, 1989, p. 331 (Table 7, Study 2)

Over time, the original model by was extended through the addition of other constructs (Granić, 2023, 186ff): perceived enjoyment, conformity behaviour, and self-esteem (Yu, 2020); perceived playfulness (Lin and Yeh, 2019); and privacy, infrastructure, institutional support, and access devices (Aburagaga, Agoyi, and Elgedawy (2020)

The Decomposed Theory of Planned Behavior (DTPB) combines TPB and TAM to depict specific beliefs as decomposed into belief constructs (Taylor & Todd, 1995, 147). Factors that impact the acceptance and usage of a technology include: attitude (perceived ease to use, perceived usefulness, and compatibility), subjective norm (peer influence and superior influence), and perceived behavioural control factors (self-efficacy, resource-facilitating conditions, and information technology support).

Concerns-Based Adoption Model

According to Straub (2009) “technology adoption is a complex, inherently social, developmental process; individuals construct unique yet malleable perceptions of technology that influence their adoption decisions. Thus, successfully facilitating technology adoption must address cognitive, emotional, and contextual concerns.” Accordingly, the Concerns-Based Adoption Model (CBAN) “includes three diagnostic, judgement-free components, the Stages of Concern (SoC) survey; Levels of Use (LoU) interviews; and Innovation Configuration Maps (ICM). Through 35 survey items, the SoC survey identifies individual attitudes and beliefs of change agents and how they align with the innovation” (Olson, et al., 2020, 50) while the LoU identifies stages of use of the innovation, ranging from ‘novice’ to ‘advanced user’.

Unified Theory of Acceptance and Use of Technology

Following a review of technology acceptance models (including those listed above), Venkatesh, et al. (2003) extracted common factors tested a model called the Unified Theory of Acceptance and Use of Technology (UTAUT), “which posits three direct determinants of intention to use (performance expectancy, effort expectancy, and social influence) and two direct determinants of usage behavior (intention and facilitating conditions). Significant moderating influences of experience, voluntariness, gender, and age were confirmed as integral features of UTAUT” (Ibid., 467).

Barriers to Technology Adoption

While the acceptance models discussed above focus on factors influencing technology adoption, it is often useful to focus on the barriers specifically, as for example by Reid (2014). “Unavailable technology is an obvious barrier. Less obvious are the reliability and complexity of available instructional technologies. Because

these can be complex, faculty with poor self-efficacy may be reluctant to try them. If a technology is unreliable, faculty turning away from it will influence others to do the same" (386-7).

A comparison of the specific categories identified by Reid and the factors discussed in the acceptance models will reveal a significant degree of overlap. In Reid, however, the point of view or perspective of the person adopting technology assumes greater importance. For example, “Leadership may not understand the complexities of the technologies, or the time needed to master them” (394). This creates a need to study technology adoption from the perspective of different and specific roles within the organization.

Risk Management

Risk Assessment Models

Risk assessment models measure an organization’s exposure to negative consequences as a result of a policy or plan, including in the present case the risks associated with the adoption of new learning technologies. Risk assessment evaluations may be qualitative, quantitative, or a combination of both (for example, by converting responses on a qualitative scale to numerical values (Kokangül et al, 2017, 26)). Risk assessments are usually subjective, measuring ‘perceived’ or ‘expected’ risk, though sometimes objective risk assessments can be derived from physical or mathematical properties of the environment being assessed.

Fine-Kinney method

The Fine-Kinney method of risk assessment (Fine, 1971; Kinney, 1976) calculates a risk score based on the product of scores for probability, exposure, and consequences. Each is weighted equally; later modifications vary the weighting.

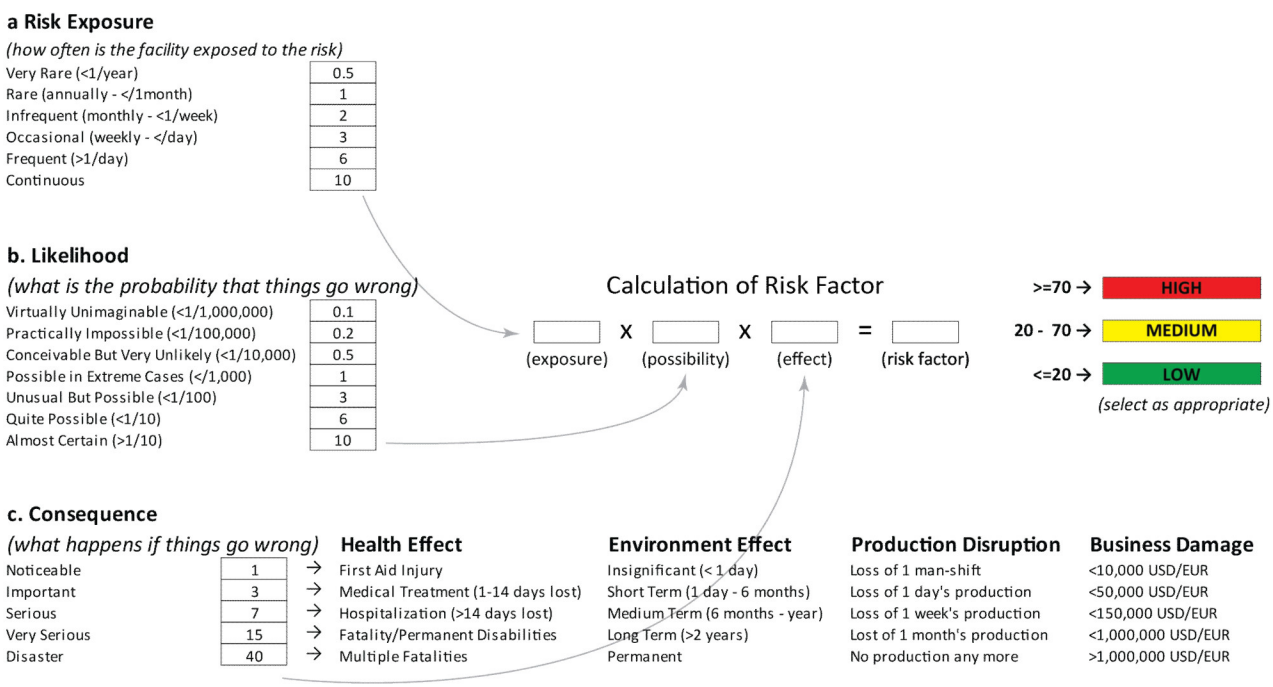

Figure 2 Risk Factors. By the Authors. Adapted from Enhesa. https://support.enhesa.com/hc/en-us/articles/360043232272-Fine-Kinney-Risk-Ranking-Methodology

Analytical Hierarchy Process Model

The Analytical Hierarchy Process model is a method for weighting and combining multiple goals or outcomes and multiple criteria in order to obtain weighted outcomes (Harker, 1989, 8). Risks are assessed using a risk classification scheme organizing risk factors according to categories, for example, 'acts of god', 'financial', 'design', etc., with subfactors being identified under each, forming a hierarchy (Mustafa and Al-Bahar, 1991, 48).

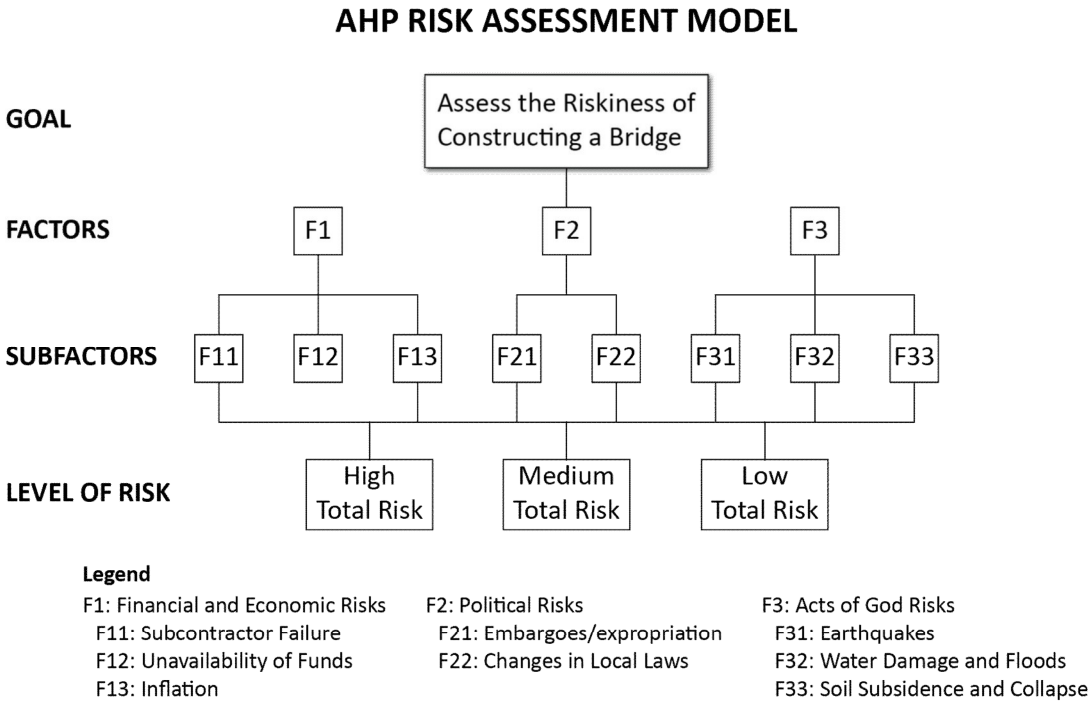

Figure 3 – AHP Risk Assessment Model. By the authors. Adapted from Mustafa and Al-Bahar, 1991, 48

Risk Matrix

A risk matrix combines the first two elements of the Fine-Kinney model. For example, the U.S. Department of Defense describes it as follows: "Consistent predefined likelihood and consequence criteria provide a structured means for evaluating risks so decision makers and program office staff can make objective comparisons" (DOD, 2017, 23). Risks may be further weighted by other factors, for example, cost to mitigate (Ibid. 29). A red-yellow-green colour scheme is characteristically employed to illustrate the final risk score. A risk assessment may be combined with an 'opportunity management' calculation in order to weight benefits in addition (Ibid. 43).

Validation

Studies such as the one described in this report are subject to the reliability and validity assessment to determine how well they measure the phenomena they are investigating; as commonly understood, reliability refers to the consistency of a measure, while validity refers to the accuracy of a measure. The measures surveyed here take into account both aspects, and the list is drawn both from formal studies of research assessment (AERA, 2014) as well as literature related to more specific forms of assessment.

Content Validity

An assessment of content validity concerns the degree of correlation of test scores with external criteria (Cureton (1951) in Sireci, 1998, 88) and includes elements of content representativeness and content relevance (Messick, 1975) or process (Tenopyr, 1977).

Content validity involves assessing whether the questions in the survey cover the entire range of issues or concepts being studied. This is done by having subject matter experts review the survey questions to ensure that they are relevant, appropriate, and comprehensive (Olsen, 2010, 136).

Construct Validity

Construct validity is similar to content validity, though it refers specifically to the structure or construction of the concept intended to be measured. This construct may be depicted using a Rasch model, which defines how data should be structured in order to obtain measurements from it. In a Likert survey, where respondents the option that best describes their attitudes, beliefs, and experiences, the Rasch model measures such factors as the unidimensionality and local independence of those options (Yamashita, 2022, 4).

Construct validity may be assessed by testing the survey and comparing the results with established measures of the same concept. This may be represented as a mapping of the questions in the survey or questionnaire to the structure of the concept being measured, and determination that response options do not overlap or extend beyond the construct being measured.

Criterion Validity

Wikipedia defines criterion validity, or criterion-related validity, as “the extent to which an operationalization of a construct, such as a test, relates to, or predicts, a theoretical representation of the construct - the criterion". For example, if the test measures X as a barrier to Y, then in a model of the concept, the unmitigated presence of X would predict an absence of Y.

The American Educational Research Association (AERA, 2014, 29) recommends that "the description of each criterion variable should include evidence concerning its reliability, the extent to which it represents the intended construct (e.g., task performance on the job), and the extent to which it is likely to be influenced by extraneous sources of variance." In any systems model, this extent may be high. That is, to continue the example, the description considers additional or alternative explanations for the absence of Y.

Criterion validity involves comparing the survey results with another established measure of the same construct to ensure that they are consistent (Fink, 2010). For example, if a survey is measuring job satisfaction, the results could be compared with another established job satisfaction scale.

Test-Retest Reliability

Typically, test-retest reliability involves administering the survey twice to the same group of people and comparing the results to ensure that they are consistent. This is done to assess the stability of the survey over time. As AERSA (2014, 39) states, "The overall reliability/precision, given error variance due to the sampling of forms, occasions, and raters, can be estimated through a test-retest study involving different forms administered on different occasions and scored by different raters."

In some cases, it may be impractical to administer the same survey to the same people, as the application of the survey the first time may influence responses the second time, particularly when the survey is administered in the context of a focus group. In such a case, it may be sufficient to administer the same survey twice to the same *type* of people. The focus of test-retest is to assess the questions, not the specific individuals; “Information about random fluctuations in scores is essential for understanding the reliability of change scores—that is, for distinguishing random short-term score differences from true improvements or deteriorations over time” (Polit, 2014, 1714).

Internal Consistency

Internal consistency involves assessing the extent to which the questions in the survey are measuring the same construct. For example, if some questions are asking about the objective existence of an entity, and other questions are asking about a respondent’s perceptions of an entity, the questions are not measuring the same construct. Assessment of internal consistency may be considered conceptually, as in the example just given, or by using statistical techniques such as coefficient alpha to assess the inter-correlation between the survey items (Cronbach, 1951).

The coefficient alpha is “an internal-consistency reliability coefficient based on the number of parts into which a test is partitioned (e.g., items, subtests, or raters), the interrelationships of the parts, and the total test score variance.” It is also called Cronbach’s alpha and, for dichotomous items, KR-20 (AERA 2014 217). The internal-consistency coefficient is “an index of the reliability of test scores derived from the statistical interrelationships among item responses or scores on separate parts of a test” (AERA 2014 220).

To assess the internal-consistency coefficient a method such as the split-halves method may be employed, where “scores on two more-or-less parallel halves of the test (e.g., odd-numbered items and even-numbered items) are correlated, and the resulting half-test reliability coefficient is statistically adjusted to estimate reliability for the full-length test” (AERA 2014 35-36).

B. DRDC Study

Pilot

A previous pilot study was structured as follows: “Accordingly, a two-day workshop format was developed, the first day of which was spent introducing the future (Land Vehicle Crew Training System (Canada, 2020)) system, and discussing potential LVCTS use cases (as framed by participant’s roles within the training system). This set the stage during the second day for the elicitation and prioritization of potential barriers for LVCTS, and subsequent identification of potential pathways for addressing them” (Martin, Jarmasz & Kirollos, 2021, 2)

A framework for barriers

The pilot study concerned barriers to the implementation of the Land Vehicle Crew Training System (LVCTS) and was based on the following model of factors impacting technology adoption (Martin, Jarmasz, and Kirollos, 2021):

- Technology
  - T1-Access, T2-Reliability, T3-Complexity
- Process
  - P1-Project management, P2-Support to trainers and learners, P3- Technical Assistance, P4-Support Staff, P5-Recognition of learner needs, P6-Professional Development available, P7-Consideration of Collective Training
- Administration
  - A1-Instructor control of technology, A2-Institutional support for use of technology, A3-Effort Estimate, A4-Recognition of adopters, A5- Sufficient adoption time
- Environment
  - E1-Organizational Change Instructor Role, E2-Organizational Change Instructor Value, E3-Tension with established practice, E4-Legal concerns, E5-Effectiveness of Technology
- Training Stakeholders
  - TS1-Instructors effectively use technology, TS2-Instructors embrace change, TS3-Instructor ability to use technology, TS4-Instructors have positive view, TS5-Instructors receive PD

This may be compared to previous work (Jarmasz and Martin, 2018), which is adapted from Reid (2014):

- P4-Support Staff, P5-Recognition of learner needs, P6-Professional Development available, and P7-Consideration of Collective Training are added
- A4-Recognition of adopters are A5- Sufficient adoption time are added
- The item ‘Organizational change’ is split into E1-Organizational Change Instructor Role and E2-Organizational Change Instructor Value, E3-Tension with established practice is added, and there is a distinction between *assessment* of technology effectiveness and (organizational) *perception* of it
- The section on instructors as training stakeholders is expanded

It may be argued that Reid’s work is a marked departure from the models of technology adoption. However, while discussing Reid, we are less inclined to see it as a 'marked departure' because there's so much overlap on the factors considered, as it is a requirement for multiple, and more specific, perspectives. That's what is accomplished with a focus on roles. But this isn't a departure from the TAM literature; it is an extension of it.

Results and Key Takeaways

Significant results from four pilot studies were as follows:

Table 2: *Impact and Presence Ratings with the Same Response Distribution among Locations.*

Code	Barrier	Mode of Impact Rating	Mode of Presence Rating
T1	Technology – Access		Sometimes
T3	Technology – Complexity	Serious	Usually*
P1	Process – Process Management	Moderate*	Usually
P2	Process – Support to Trainers	Serious	
P5	Process – Learner Needs	Moderate*	
E2	Environment – Value of Instructor's role		Sometimes*
E4	Environment – Legal Concerns		Sometimes*
TS4	Training Stakeholders – Positive perception	Moderate*	

Note: * = most common rating after "No Observation."

Figure 4 – Impact and Presence Ratings. Reproduced with permission from Blake Martin The original can be found in Martin, Jarmasz & Kirollos, 2021, 9.

Key takeaways, ibid., quoted from p. 19:

- Assume different sites will use the system differently
- Assume future learners will need to learn different content
- Assume future trainers will want to train differently
- "Realism" can be conveyed by non-virtual components
- Visual effects and simulated realism were spoken of much more often than 6-DoF movement; however,
- the actual conversations during the focus groups very frequently steered toward full motion simulation
- Users need graded access to system features
- System must have connectivity and "relatedness"

Looking at Barriers as Pathways

It is understood that the survey is less focused on acceptance models than it is an examination of an institution, and specifically, what affordances are needed for an institution design or adapt new models and technologies to instruct and develop personnel. It is focused more on the sociology of the institution rather than the sociology of the technology. By contrast, as described above, technology acceptance models focus on individuals, not institutions.

Accordingly, Martin, Jarmasz & Kirollos (2021, 10) propose representing the barriers as 'pathways'. This offers a more institutional perspective, suggesting means and mechanisms to achieve organizational goals. Barriers are then defined in terms of the pathways. "During each (focus group), an opportunity was provided to participants to directly address and find pathways for selected barriers which they deemed most salient… these pathways are intended to provoke discussion rather than prescribe solutions, and are not to be construed as a definitive list."

- Technology
  - Apply best practices for managing, applying technology
  - R&D to improve technology with user-centred design
- Process
  - Institutionalize Professional Development for Distributed Sim
  - R&D to further develop collective training theory
  - R&D on tools for collective training support (e.g., scenario generation)
- Administration

    - Institutional commitment to providing resources for distributed sim
    - Develop policies & strategies supporting distributed sim
    - Research to understand true cost & value of distributed sim
- Environment
    - Top-down buy-in
    - Concerted institutional effort at culture change
    - Research on training effectiveness of distributed simulation
- Training Stakeholders
    - PD to improve instructor skills, self-efficacy
    - R&D on training support tools (e.g., automated measures, content authoring)

Though not founded in technology acceptance models, there is a significant overlap, and it is arguable that the models provide guidance for the development of pathways, because in many respects, the actions of an organization depend on the actions of individuals.

Looking at Barriers as Risks

The pilot study as well as the study adopt a hierarchal framework describing barriers to technology adoption (Reid, 2014), consistent with the Analytical Hierarchy Process model, as follows:

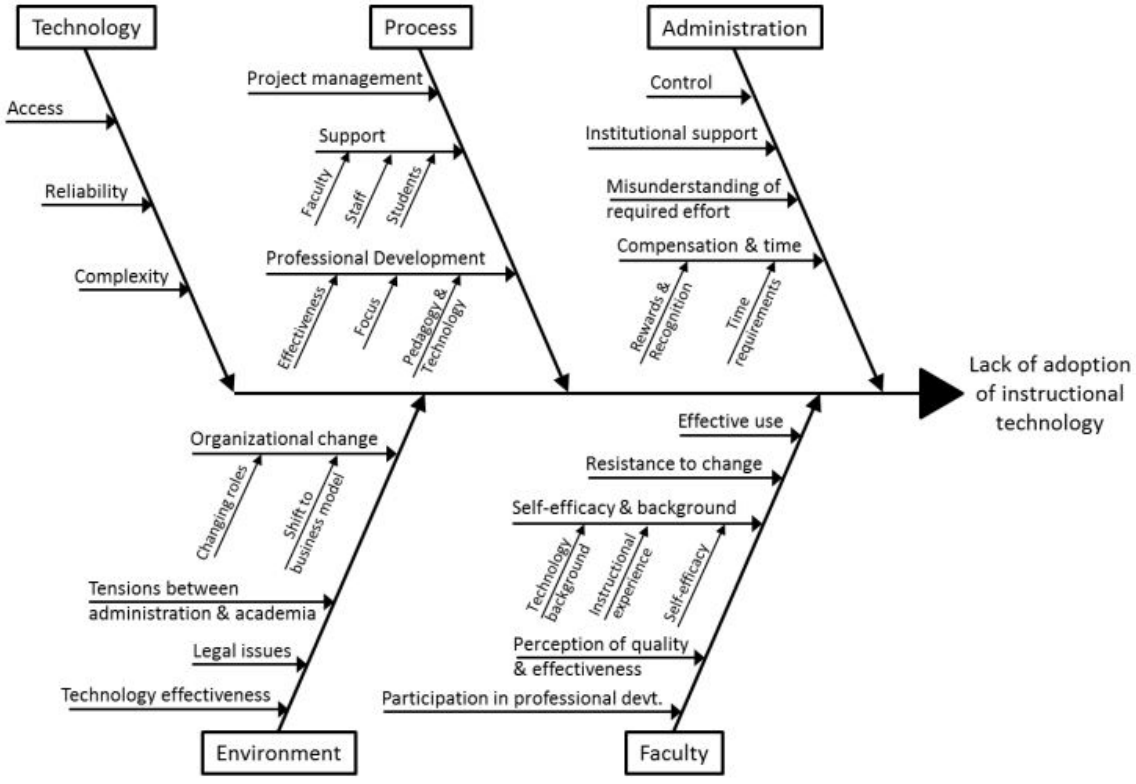

Figure 5 - A conceptual framework describing the causal factors that can act as barriers to the adoption of instructional technologies. Reproduced with permission from Blake Martin. The original can be found in Bennett, et al, 2020, 13, adapted from Reid (2014).

Questions addressing each of the categories and subcategories were designed following a risk assessment matrix model, as described above. Hence, respondents were asked to report on both the likelihood of a given outcome, as well as the impact of this outcome.

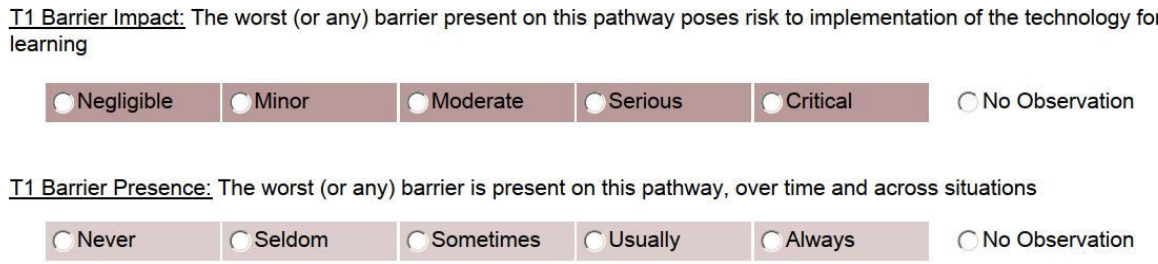

Figure 6 - Example of a question posed in a specific risk category, in two parts. Barriers and Pathways Questionnaire, 5. Reproduced with permission from Blake Martin from unpublished PDF survey.

The framing of technology barriers as risks is consistent with extant risk management literature. As an overall methodology, therefore, this approach is sound, though additional discussion on categories, wording of questions, and the range of options, will be undertaken below.

Study Overview

In the study, questions are again represented as pathways:

Barrier Category	No.	Subcategory (in brief)
Technology	T1	All learners and trainers have *access* to use the technology resource, equally across departments or groups.
Technology	T2	The technology is *reliable* when used over time and varied situations.
Technology	T3	The *complexity* of the technology does not impair its usability.
Process	P1	Project Management approach *anticipates and works to eliminate problems* in using the technology.
Process	P2	Leadership and other stakeholders provide *support* to trainers, learners, and staff to effectively adopt the technology.
Process	P3	*Technical Assistance* for the technology is approachable, available when needed, and knowledgeable.
Process	P4	Support staff with skills needed for working with trainers and learners, *facilitate technology use*.
Process	P5	The organization *recognizes learner needs* by encouraging development of new models of teaching and new approaches to learning.
Process	P6	*Professional Development* is available to Teachers/Trainers.
Process	P7	*Collective Training concerns* are considered.
Administration	A1	*Teachers/trainers control* what technology gets used and how.
Administration	A2	There is evidence for *perceived institutional support* by the organization for adoption of the new technology.
Administration	A3	The *required effort* to implement the new technology is appropriately estimated, preventing abandonment.
Administration	A4	The organization appropriately *recognizes and compensates* the effort of the personnel adopting the new technology.
Administration	A5	The organization provides *sufficient time* to use and learn the new technology, adapt or create new learning opportunities, and to deal with technical problems.

Environment	E1	*Organizational change* is effectively managed to anticipate the *shifting role* of Teachers/ Trainers.
Environment	E2	*Organizational change* is effectively managed to *reduce fear* that the technology will not reduce the value or autonomy of the trainers.
Environment	E3	*No tension* with established or enculturated training practices or contrary knowledge of the trainers.
Environment	E4	There are no *legal concerns* created by required military customization of the technology.
Environment	E5	The technology's effectiveness has been *carefully assessed*.
Training Stakeholders	TS1	The Teachers/Trainers can *effectively use* the technology.
Training Stakeholders	TS2	The Teachers/Trainers *embrace change*.
Training Stakeholders	TS3	The Teachers/Trainers *have background* with respect to technical understanding and instructional experience, and *believe in their own ability* to use the technology.
Training Stakeholders	TS4	The Teachers/Trainers have a *positive perception* of the instructional technology's effectiveness.
Training Stakeholders	TS5	The Teachers/Trainers are *willing to participate* in relevant professional development.

Figure 7- Questions represented as pathways. Reproduced with permission from Blake Martin from unpublished PDF survey.

General Considerations

The survey reflects a fine line between objective assessments of the state of affairs of technology adoption, and the individual's perceptions as they may impact technology adoption (or even, an objective assessment of perceptions that may adopt technology adoption). Are respondents talking about other people, or are they talking about themselves? Lack of clarity on this could create a fuzziness in the results.

We can ask, is there a way that people can be a representative of their 'kind'? For example, if someone asked about work conditions for scientists at NRC, one would of course be answering for themselves, but could probably also provide some general insight about the situation for NRC scientists. Could both be true? Perhaps, but even so, but it would be important to distinguish between them. A person can be " a special case" or "a typical researcher", but probably not at the same time.

Additionally, individual perceptions are influenced not only by their own experience but also as experienced either by behaviour that is modelled by others or even through broadcast and social media (Bandura, 1986), a factor that is reflected through most assessments of perceived barriers to technology adoption. This study does not reflect these social experiences as barriers to adoption, though some models identify them as such (e.g. Azjen, 1985, 28).

Scales

As noted above, two scales for each impact factor are employed, one measuring the risk factor, the other the impact. It should be noted that the risk factor is introduced as a pathway. This, the model is generally:

- Pathway: X does Y
- Assessment:
    - The impact of the worst (or some) barrier to Y is: range: negligible to critical
    - The likelihood of the barrier is: range: never to always

The range of responses is ordered in the manner of a Likert scale, that is, it is ordered, and allows a selection from a range of responses, and neutral with respect to the desirability of one or another response. In addition to measuring agreement or disagreement with a statement, Likert scales can be used to measure other ranges of options:

Agreement	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Frequency	Always	Often	Sometimes	Rarely	Never
Importance	Very Important	Important	Moderately Important	Slightly Important	Unimportant
Quality	Excellent	Good	Fair	Poor	Very Poor
Likelihood	Almost Always True	Usually True	Occasionally True	Usually Not True	Rarely True
Likelihood	Definitely	Probably	Possibly	Probably Not	Definitely Not

Figure 8 - Likert scales. By the authors. Adapted from Mcleod, 2023.

Though it is assumed that the options are spaced at consistent intervals, this is not always the case. In particular, options at the end-points expressing a universal (for example: ‘never’, ‘always’, ‘zero’) are at extremes, meaning they may be more or less likely to be selected than other options (Joshi, et al., 2015, 401).

The following considerations arise:

- With respect to ‘barrier presence’, is the survey measuring frequency or likelihood? All else being equal, are respondents as likely to respond ‘always’ as ‘usually’? Is the meaning of ‘usually’ the same as the more commonly used ‘often’? Is there a reason for the placement of ‘never’ at the beginning (i.e., the left) of the scale, rather than to the right (where it is more commonly found)?
- With respect to ‘barrier impact’, can the terms employed (from ‘negligible’ to ‘critical’) be thought of as value-laden? Do they reflect the measurement of a perception, with which a person may agree or disagree, or the measurement of an objective fact?
- Questions ask about “the worst (or any) barrier present on this pathway…” Though not stated, the text in these questions appears to refer to the examples provided by the respondent. However, it is not clear whether the respondent is intended to select ‘the worst’ (however evaluated) barrier or ‘any’ barrier.

Roles

The survey in its current form requests that respondents define a specific role that serves as the context for the survey. This focus on a particular role may be artificial; people may well identify with multiple roles, and there may be a distinction between a personal response and a role-based response. Given that many technology models identify personal, rather than role-based, factors in technology selection, a number of considerations arise.

Additionally, the emphasis on role may suggest to the respondent an intention to adopt an organizationally-based stance, a ‘view from nowhere’. rather than a stance informed by the respondent’s own personal experience. These might result in very different responses. For example, the organizational response to “the

organization appropriately recognizes and compensates the effort of the personnel adopting the new technology" might be "of course we do" while the personal response might be "I haven't seen it."

Two specific concerns arise:

- It might not be clear to the respondent what stance they are intended to adopt as a respondent to the survey; even if this is made clear in the focus group, this clarity may be obscured in subsequent reports or documentation of survey results.
- It is not clear that an organization-based or role-based response would result in the most valid or reliable data. Additionally, the presentation of technology barriers as risks rather than perceptions or experiences may additionally have an impact on validity, especially from respondents who have not been trained in the process of risk assessment.

Again, the question of multiple perspectives arises. It may be argued that the definition of 'role' is important as it allows us to understand that the nature of responses may be determined through the lens of role. For example, if an instructor tells you that the technology breaks down because it is unreliable and a maintenance person tells you a technology breaks down because instructors misuse it, the solution will be more nuanced. The role definition adds context. Such an example, however, is a case where the roles rarely, if ever, overlap. But we can imagine a case where one person is a maintenance person and also an instructor. If we just describe this person's response by role, it is being misrepresented; it's not actually a description of the role, it's a reflection of the person.

It is understood that the survey attempts to get people of differing backgrounds to identify a way they work with the technology, which they would identify a primary role, so each role category is represented by specific individuals. In particular, the desire is to ensure the survey is not filled only by users or only by administrators.

Validity

Content validity for the study is based on expert review from the perspective of known factors of technology acceptance and, with respect to the specific approach undertaken in the current study, assessment of risk management strategies. It is noted that the proposed questionnaire does address the broad range of factors raised in the literature.

The construct validity of the Likert scales used in the questionnaire were assessed in this review. Several concerns were noted. In some cases, it appeared that questions were compound questions, that is, they measured two factors simultaneously. In other cases, questions appeared vague. Specific examples are offered in the next section. It was also not clear that the questions in the survey mapped consistently to the selection of options available. For example, regarding the assertion "The organization appropriately recognizes and compensates the effort of the personnel adopting the new technology," the question "The worst (or any) barrier present on this pathway poses risk to implementation of the technology for learning," with options ranging from 'negligible' to 'critical' being offered.

The study does not include a method for comparing results obtained with similar measures of technology adoption in similar domains, though as noted, the survey construction is drawn from previous work, specifically Reid (2014).

The study will be applied to varying cohorts, so an element of test-retest reliability is in place. However, it is not clear whether the mode of applying the survey (that is, in a focus group) and the nature of specific occupational groups introduces or eliminates variability in responses, and it is not possible to apply a retest strategy in a focus group context. Employing the survey in different occupational groups helps address this concern - during the LVCTS collection, and will be used 5 times with subsets of a population for another collection - but it is not possible to evaluate the effect if the focus-group method unless it is compared with an alternative method that does not use a focus group.

Though the domain of the study apparently applies to a single construct, no formal study of internal consistency has been conducted, and as is noted in the specific considerations (below) there are cases where, at least on a conceptual basis, inconsistency may occur. As suggested above, for example, some questions seem to be asking about the objective existence of an entity, and other questions may be asking about a respondent's perceptions of an entity, which could signify an internal inconsistency.

Specific Considerations

This section studies the questions in the survey one-by one and identifies specific issues that arise; here we can see where the more general issues identified in this study arise.

Instructions and Process

It is important to place all instructions and descriptions of survey methodology at the top of the document. Specific steps in the instructions should be explicitly highlighted and placed up front, next to a definition of the technologies being discussed, and with information about the process.

A common format is employed for each pathway:

- The title and statement of the pathway
- Instructions and three boxes provided in which respondents can give examples of barriers to the pathway
- Two Likert scales measuring the respondent's assessment of the 'impact' and 'presence' of a barrier.

The following considerations arise:

- Respondents are asked to 'identify' barriers, but it may be clearer to ask them to 'describe' the barriers.
- It is not clear whether the size of the box represents a limit on the length of the response requested; it would be better to say 'use as much text as you need; the boxes will expand'.
- The process creates an incentive for a person to select 'no observation', since it's much easier to just do that than to think of and describe examples. It may be preferable to ask respondents to identify *possible* barriers, as that eliminates the 'no examples' option, and since 'never' is an option on the scale for barrier presence.
- It is not clear why up to three barriers are identified but only one of these is evaluated on the Likert scales. It may be worth attempting an alternative format:
    - Provide respondents with the pathway description
    - Have them identify as many possible barriers as they can imagine
    - Provide an assessment of the likelihood and impact of each barrier
- It's good to use of underlining to provide tooltip definitions. However, not everything that is underlined offers a tooltip, so a formatting change is recommended.

Categories

- T3 – poses a question about usability, which is something objectively measured in formal usability tests (Lewis & Sauro, 2021, 972), rather than asking a question about whether the technology causes confusion or seems inappropriate for educational use

Process

"Process refers to systems and procedures needed to identify, procure, implement and promote…" and evaluate "…the use of a new technology."

- P1 - In Reid (2014) the project management approach is expressed in terms of whether staff and users are consulted, as opposed to whether it "anticipates and works to eliminate problems in using the technology." Additionally, the question asks about "assessing learner needs", "development of a training plan", "specific goals and milestones to measure success." It thus combines a number of different factors, resulting in a complex question.
- P2 – is a compound question (i.e., a conjunction of two distinct questions) – "Leadership and other stakeholders…"
- P3 – It is not clear whether 'Technical Assistance' means 'technical support only' or 'technical support plus something else', such as training or additional tools and resources.
- P? – a question about the appropriateness of the adoption plan (if any, from the perspective of people who may or may not follow it) is not asked (labelled 'P?' because it does not correspond to any specific subsection of the survey)
- P5 – the question asks whether "the organization recognizes learner needs by encouraging development of new models of teaching and new approaches to learning." It is not clear the respondent will know whether the institution is developing new theory or whether the question refers to helping people develop skills in new methods?
- P6 – It may be better to more explicitly state whether professional development includes things that are not traditional training, such as job aids, communities or practice.
- P7 – The respondent may not know that 'collective training concerns' refers to the training of groups or cohorts, and the meaning may be unclear to people reading the survey results.

Administration

- A2 – It is not clear what "evidence of a perception" would be.
- A? – It would be desirable to ask whether respondents see administration set an example by using the technology as well, as this is a factor frequently mentioned in technology adoption literature (labelled 'A?' because it does not correspond to any specific subsection of the survey)
  .
- A3 – a complex question is being asked. It is not clear whether 'abandonment' the standard being measured, or effort generally?
- A4 – the question asks whether "organization appropriately recognizes and compensates the effort." The respondent might not know. The term 'compensation' is vague, and suggests a relation to pay, leave, or other unspecified benefits. It is not clear whether 'effort' is being compensated, or whether a measurable parameter, such as 'the use of the technology', is being measured.

Organizational Change

Organizational change pathways are represented as follows:

- E1: Organizational change is effectively managed to anticipate the shifting role of Teachers/Trainers who may take on extra responsibilities and require additional trouble-shooting skills, and technological familiarity as a consequence of the new technology.
- E2: Organizational change is effectively managed to reduce fear that demands for improved learning at lower costs through the technology will not reduce the value or autonomy of the trainers.

In both cases, 'organizational change' is represented passively, with no agent of organizational change identified. It is described as the agency for 'articulating the shifting role' and 'reducing fear' respectively.

This in both cases creates a complex question: first, whether the impact on role or fear has happened, and second, whether organizational change is responsible for this impact.

Business Model

- E? – questions about 'business model' or 'business' focus' have been dropped. While it is understood that the survey is not being applied in a business or commercial context, the concept of a 'business model' remains relevant in the context of technology procurement and deployment (Davies, 2015, 5) and would be relevant in a technology barriers survey (labelled 'E?' because it does not correspond to any specific subsection of the survey).

Environment

Questions E3, E4 and E5 ask about states of affairs in the environment, specifically:

- Whether "demands for improved efficiency, new training or educational priorities and policy changes are in tension with established or enculturated training practices or contrary knowledge of the trainers"
- Whether there are "there are legal concerns created by required military customization of the technology beyond a consumer off-the-shelf model, military methods of procurement, or military ownership of intellectual property."
- Whether "the technology's effectiveness has been carefully assessed against training objectives by scientific study, systematic use across instructors, and proof in non-permissive environments."

It seems likely that respondents will not have the knowledge or capacity to answer these questions as stated. This is especially the case with the second, which seems to require some background in law, but the first and third also ask about the actions or beliefs of third parties.

The third is also vague about agency, similar to the issue identified under 'organizational change', above.

Question E5 asks, "The technology's effectiveness has been carefully assessed against training objectives by scientific study, systematic use across instructors, and proof in non-permissive environments." This may well be beyond the capacity of the respondent to answer.

Organizational Culture

Question E3 states, "Demands for improved efficiency, new training or educational priorities and policy changes are not in tension with established or enculturated training practices or contrary knowledge of the trainers," which is specifically a question about organizational culture.

The question thus extends beyond Reid's model, but reasonably so, as organizational culture, including training culture, can undeniably have an impact on technology adoption. This impact may be complex and broken down into numerous factors (Melitski, Gavin and Gavin, 2010, 555) and is thus a complex question. Because of this, questioners and respondents may be referencing different aspects of organizational culture.

As is stated more generally below in the recommendations, specific questions would be preferable, for example, asking whether there is a contrast between what they are asked to do and the criteria against which they are evaluated, or whether the level of decision-making is consistent with the setting of requirements.

Training Stakeholders

- TS1 – this question asks whether teachers and trainers can effectively use the technology. It is not clear which technology is being referenced: the technology used to provide the training, or the technology about which training is being provided.
- It is also unclear what would constitute evidence for 'can effectively use'. This question could refer to the skill or the trainer, or the quality of the technology. It could also be the result of an objective assessment (for example, having passed a course on the technology) or the respondent's subjective assessment.
- TS2 – asking whether teachers or trainers "embrace change" is probably inappropriate. Once again, one wonders how the respondents would be in a position to know. Questions should ask about specific instances, for example, "teachers or trainers have expressed negative views about the technology".
- TS3 – asks two separate questions, and requires a single response. If both questions are important, they should be asked separately. Also, again, 'the technology' is unclear – do we mean *this* technology, or technology in general?
- TS4 – this question asks a question the respondent may be unable to answer, as it asks about the trainers' or teachers' perceptions and beliefs. This also may be a complex question, depending on whether there is a difference between "have a positive perception of the instructional technology's effectiveness" and "believes the technology is effective".

C. Recommendations

Validation

Specific recommendations regarding construct validation are discussed below (in 'Survey Contents').

Criterion Validation

The survey should be validated against similar surveys of technological barriers in similar (and preferably military) domains. Ideally, before the survey is conducted, an exercise should be conducted whereby the results of the survey (for example, correlations between job function and perception of a barrier impact) are predicted, or at least, compared, with the other survey.

Test-Retest Reliability

Survey questions should be tested in other contexts to assess reliability. In particular, because the focus group method does not allow for a test-retest process, it is very difficult to assess the reliability of questions, hence, a shorter version of the survey should be applied as a questionnaire to similar target populations and an assessment of measurement reliability conducted (that is, whether similar people in similar contexts produce similar results).

Format and Process

Continuation as Focus Group

The survey should continue to be administered in the context of a focus group. The survey by itself is an exhaustive (and exhausting) examination of barriers. It should not be simply released as a survey, since it may take an hour to complete. It would be much more effective as an aid to an in-person session where a person leads the discussion and answers questions as they come up, and then either (a) people record their answers during the session, or better (b) a recorder or scribe fills in the information about the examples as the session proceeds.

Clarity of Perspective

Clearly define when personal perspective or objective assessments are required. It should be noted that in the development of technology and adoption models a distinction is drawn between adoption theory, which examines the individual and the choices an individual makes, and diffusion, understood in terms of the spread of an innovation across an organization over time." (Straub, 2009, 626). Individual perceptions may be an accurate guide to the former, but misinformed about the latter.

As noted previously, the survey reflects a fine line between objective assessments and the individual's perceptions. It is important that this line be clearly identified and negotiated during the focus group sessions, and additionally, that all direction to the respondent regarding personal stance, perspective or point of view be clearly defined in survey results.

We might ask, can we somehow walk the line between speaking to personal experience and including observations of the field in which the observer stands? Such a question, though, shows the importance of clarity of perspective. The line is between "objective assessments and the individual's perceptions", not between 'experience' and 'observations'.

For example, consider a statement about a crowd size. There is a fact of the matter - 12,321 people, say. Then there's the perception - "there were thousands of people", say. What would "walking the line" between these be? Specifically, if we are asking about a fact of the matter, then we should be expecting an answer like "12,321 people", which is not an estimate or a guess, etc., but an actual statement of fact (and perhaps verified by some measurement system). If we do not expect an answer like this, then we are not asking for a fact of the matter, and should be clear that what we expect as a result is a perception.

Validate Role Definition

The impact of requiring respondents to take a role-based or organizational perspective should be studied. As noted above, requiring an organization-based or role-based response, and, the presentation of technology barriers as organizational risks may impact the validity of the survey results. It should be noted that evidence one way or another regarding this question was not found in the research.

Scales

Provide as much guidance as possible to respondents regarding how barriers are described. A Likert-style survey generally poses a statement or assertion designed to be as neutral as possible, and then asks for respondents to express their opinions about the statement. Because the response is a single value, it is important for the question to be as specific as possible. However, in this survey, the pathways presented are complex and sometimes vague; there are specific recommendations about wording below, but some of this may be unavoidable. Then there are the barriers – which are what the Likert scales *actually* measure – but these are at the time of the survey undefined, and are provided by the respondents themselves.

It will be important to provide as much guidance as possible to respondents regarding how barriers are described in order for the scales to be meaningful. In particular, respondents should be instructed as follows:

- A barrier must be a single specific item
- It must be the sort of thing that can be observed or believed by the respondent
- The directionality of statements must be clear and consistent (e.g.., respondents should not define one barrier as 'working technology' and another barrier as 'no instructions')

In discussion the researchers considered a variety of permutations where the scales had a neutral mid value and moved toward negative and positive values on either end. For example:

- The reliability of the technology strongly impedes its use

- The reliability of the technology impedes its use
- The reliability of the technology neither impedes nor enables its use
- The reliability of the technology enables its use
- The reliability of the technology strongly enables its use

However, it was felt that this approach creates a complex question, where the separate questions are, "is the technology reliable?" and "does the reliability matter?" Even if we only ask the second question, it may be interpreted as asking about the first question, but in a way that avoids the need (or possibility) or anyone saying "the technology is unreliable". It is true that this survey isn't about the technology, it's about the organization. But the wording doesn't make that clear. This then may be further entangled by the use of pathways. The 'pathway' to use is 'reliable technology', while the barrier is 'unreliable technology'. But the two effects are different. We might not be any more or less likely to use technology simply because it's reliable, but you may be much less likely to use a technology if it's unreliable. For example, we could fly Air Canada or Westjet. If they're reliable, then it doesn't matter which airline we choose, but if one of them is unreliable, it makes a big difference.

This has the potential to be a serious issue. The barrier-pathway relationship is not symmetrical. Converting barriers to pathways changes the results, and creates a risk that the questions will be incorrectly interpreted by respondent. Respondents should be provided with as much guidance as possible as to what counts and does not count as a barrier.

Again, it is understood that the survey is being administered as a study of the organization, hence, barriers should reference properties of the organization as a whole, and not properties of (say) individuals in the organization, or factors outside the organization's control. This can be a key point about the 'unit' under consideration. However, are the individual members within an organization not part of its culture, behaviour and functioning? Is this a forest/trees situation?

It is arguably exactly a tree and forest situation, but where the methodology is asking each tree to pretend it's a forest. There are good reasons to doubt about this approach, but they may be elided by saying that we should clearly state what we're doing, and then readers who follow can draw their own conclusions about whether this is appropriate. It is beyond the scope of this study to say what that guidance should be, but the guidance should be clear, and it should be documented in the survey results, so people studying the survey can be clear about the scope.

Survey Contents

Study Social Perception

Research into social factors influencing technology adoption and diffusion be conducted. The pilot study does not address social factors that may have an impact on technology adoption. For example, the following may be factors passed through social interaction: whether the technology thought to be 'cool' or whether users (like Google Glass users) find themselves the object of ridicule; whether users get the sense that 'everyone is using it' or whether they feel they are on their own; whether there are concerns about privacy or surveillance; whether the technology is fun.

It may be argued that while this may be a valid critique, but these questions are really outside of the scope of the Barriers work, and fall more within the scope of TAM or UTAUT. After all, the starting place for the barriers study is that we can take a perfectly good technology, one that is otherwise acceptable, fun, and useful, then ask, "why does that tech fail in this ecosystem?" The starting place for the two studies is fundamentally different.

In response, however, while the starting point may be different, social factors still exist within the organizational context (or it would be a very broad assumption to say that they don't). Either way, the exclusion of social factors as being beyond the scope of this study needs to be justified. It is very reasonable to suggest that social factors would be a significant (barrier or pathway), especially in an organization with such strong social pressures and cultures as a military organization.

Either in conjunction with the current study, or as a separate study, it is recommended that research into social factors influencing adoption and diffusion be conducted.

Validate Pathway Terminology

A risk of the use of the pathway terminology is that it may make the questions more complex without adding meaning or scope to the responses. Moreover, it is not clear that people answering the survey would think in terms of 'pathways' to use, though conducting the surveys as in-person (or real-time online) focus groups would help. But it is possible that a more accessible terminology might make the survey it easier to apply.

It is possible that describing technology barriers in terms of the pathways to resolution may either change the outcome of the survey from what it would have been employing a more standard construction, or change the perception of the survey from the perspective of those taking it. It may also be the case that the description of selected pathways may not actually resolve the barriers, or may not exhaust the possible resolutions of the barriers. It may also be the case that these changes may result in more accurate or more desirable outcomes. For these reasons it is recommended that the employment of pathway terminology in the survey be validated.

Eliminate Double Negatives

Survey options should not be expressed as double negatives. Specifically, the existing framing of questions creates double negatives, which should be avoided. A 'barrier' is a factor that may prevent adoption and diffusion. For example, the complexity of a technology is a barrier (call this 'P'). A pathway is a route to addressing that barrier, for example, improving technology with user-centred design (call this 'not P'). The survey question 'T3' states "The complexity of the technology does not impair its usability" (not P). Users answer the question "The worst (or any) barrier present on this pathway poses risk to implementation of the technology for learning" (not not P) on a scale from 'Negligible' (not not not P) to 'Critical' (not not P).

It is preferable to state the question more clearly. Two possibilities exist, one that represents the barrier as a barrier and queries whether if is present, or one that adopts the 'pathways' method and asks whether or not the pathway is successful. For example:

- The complexity of the technology selected is a barrier to adoption: (range: always - sometimes - never)
- The technology selected is user-centered: (range: always - sometimes - never)

Revise Complex Questions

Complex questions should be revised. When the 'pathways' approach is employed, there is a risk of creating complex questions as a consequence of conflating agency for change with the change itself. For example, in questions E1 and E2, 'organizational change' is identified as the agent, and 'accounting for roles' and 'reducing fear' are the effects. The text of the question does not make clear whether the respondent should consider the impact of the change agent, or whether the effect actually happened, or both. In practice, complex questions like this in a survey context should be avoided.

Ask About Evidence Rather than Objective Existence

Respondents should be asked about evidence, not existence. There are cases where the respondent is asked whether something exists. For example, in E5, the question should ask whether the respondent has evidence of assessment, rather than about the objective existence of assessment, because the respondent may not be

in a position to answer the latter question. Similar considerations hold for questions about whether there are legal issues or whether trainers have certain specific knowledge. Fixing the survey construct to a single domain is essential to maintain internal consistency.

When respondents are asked about questions to which they do not know the answer, they may fail to respond, they may guess, or they may try to anticipate what answer the questioner is expecting, and provide that. Posing the question in the context of a focus group or group discussion, as described elsewhere, may help with this, but it may also result in the group conclusion, without foundation, that one thing or another is the case, and reporting it as such.

The presentation of the question in conjunction with a request for examples also may help with this, but it is important to ensure that the posing of the question is consistent with the examples. For example, in E5, the question posits, “the technology has been carefully assessed”, and the examples ask the respondent to “identify up to three examples of barriers that you observed,” that is, cases where the technology has *not* been assessed. A lack of examples does not entail the objective existence of the assessment.

Specify Which Technology is Being Discussed

Questions should reflect what technology is being discussed, even if it is clear through context to the respondents. In most cases of the application of this survey it is known what training technology is under discussion. This, for example, is the case with LVCTS.

In some instances, however, the term ‘technology’ is employed in such a way as to create ambiguity between whether it is discussing the specific technology, or whether it is discussing technology in general. This is especially the case where the question does not concern the technology directly, as for example in the section on training support.

Questions should be posed in such a way as to ensure there is no ambiguity about which technology is being discussed. While the technology being discussed may be clear in the focus group, this information could be in the distribution of a survey, or in subsequent analyses of survey results. Hence the technology discussed should be inserted into survey text)

Specify Which Barrier if Being Discussed

Clearly instruct respondents how to select which barrier to address. It is not clear whether the respondent is intended to select ‘the worst’ (however evaluated) barrier or ‘any’ barrier, leaving it unclear which barrier they have selected and whether it is the worst. It is recommended to have participants identify one barrier as ‘the worst’ (perhaps with an explanation), and to refer to that barrier specifically when asking about impact and presence.

A suggested wording follows:

1. “Identify whether or not in your role, you saw examples of a pathway or barrier at the observed organizational level during the specified exposure.”
2. “Considering the instance of the worst barrier, rate the degree to which the barrier was absent or present.”
3. “Then, estimate, in your opinion, how that barrier would impact the successful use of the technology.”

Concluding Remarks

The survey evaluated in this report is being used to identify factors that may be acting as barriers to the implementation and use of learning technologies in training.

There is a broad literature concerning technology adoption, and this literature must be considered in any assessment of this sort. This research considers the impact of a wide range of factors, and not just the technology itself and attitudes regarding it. The study authors draw on an approach proposed by Reid (2014) that stresses the importance of the ecosystem or environment of the organization.

The survey consists of an extensive set of questions covering the categories described by Reid, intended to be employed in the context of a focus group. An analysis of the survey finds broad adherence to the research results found in the literature. Factors identified in both technology acceptance models and in Reid's extension are taken into account. In particular, the design of the study takes into account individual roles and perceptions of the various factors, providing more specific insights a more general study would likely miss. The study also represents barriers in the form of 'pathways' and can also be seen as representing them as 'risks'.

This review is the first part of a validation process, necessary in order to ensure that the survey measures what it is intended to measure, and does so reliably. It would be useful to extend validation using additional measures as well. Certainly, the survey should continue to be administered as a focus group. Because of the modifications undertaken in order to obtain better results, it is necessary to be clear about what is being asked and who is being asked, and the terminology employed in representing barriers as pathways can sometimes be confusing. With the need for such clarity fully articulated, the survey can be used to obtain precise and useful data regarding the adoption of learning technology in a specific organizational context.

References

Ajzen, I. (1985). From Intentions to Actions: A Theory of Planned Behavior. In: Kuhl, J., Beckmann, J. (eds) *Action Control*. SSSP Springer Series in Social Psychology. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-69746-3_2

American Educational Research Association. (2014) Standards for Educational and Psychological Testing. https://www.testingstandards.net/uploads/7/6/6/4/76643089/9780935302356.pdf

Bandura, A., Ross, D., & Ross, S. A. (1963). *Vicarious reinforcement and imitative learning. The Journal of Abnormal and Social Psychology, 67(6), 601–607.* doi:10.1037/h0045550

Bandura A. (2001). Social cognitive theory: an agentic perspective. *Annual Review of Psychology*. 2001; 52:1-26. doi: 10.1146/annurev.psych.52.1.1. PMID: 11148297.

Bennett, W, et al. (2020). 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. The Technical Cooperation Program.

Berge, Z. L., & Muilenburg, L. (2001). Obstacle faced at various stages of capability regarding education in institutions of higher education: Survey results. *TechTrends*, 46(4), 40–45.

Canada. (2020). Land Vehicle Crew Training System http://dgpaapp.forces.gc.ca/en/defence-capabilities-blueprint/project-details.asp?id=1697

Cronbach, Lee J. (1951). "Coefficient alpha and the internal structure of tests". *Psychometrika*. Springer Science and Business Media LLC. 16. (3): 297–334. https://link.springer.com/article/10.1007/BF02310555

Davis, F. D. (1989), "Perceived usefulness, perceived ease of use, and user acceptance of information technology", MIS Quarterly, 13 (3): 319–340. https://www.jstor.org/stable/249008

Davies, C. (2015). *Canadian Military Journal* Vol. 15, No. 2, Spring 2015, 5-15. http://www.journal.forces.gc.ca/vol15/no2/PDF/CMJ152Ep5.pdf

Department of Defense (U.S.). 2017. Department of Defense Risk, Issue, and Opportunity Management Guide for Defense Acquisition Program. https://web.archive.org/web/20170704192215/https://www.acq.osd.mil/se/docs/2017-RIO.pdf#page=36

Fine, W. T. (1971). Mathematical evaluations for controlling hazards. *Journal of Safety Research*, 3(4), 157–166. https://apps.dtic.mil/sti/citations/AD0722011

Fink, A. (2010). Survey Research Methods. In International Encyclopedia of Education (Third Edition), Penelope Peterson, Eva Baker, Barry McGaw, eds., pp. 152-160. Elsevier. https://doi.org/10.1016/B978-0-08-044894-7.00296-7

Granić, A. (2023). Technology Acceptance and Adoption in Education. In: Zawacki-Richter, O., Jung, I. (eds) *Handbook of Open, Distance and Digital Education*. Springer, Singapore. https://doi.org/10.1007/978-981-19-2080-6_11

Harker, P. (1989). The Art and Science of Decision Making: The Analytic Hierarchy Process. In *The Analytic Hierarchy Process* (pp.3-36). Springer-Verlag, Editors: Bruce L. Golden, Edward A. Wasil, Patrick T. Harker. https://www.researchgate.net/publication/263735008_The_Art_and_Science_of_Decision_Making_The_Analytic_Hierarchy_Process

Jarmasz, J. and Martin, B. (2018). Distributed Simulation for Training: Promises, Barriers and Pathways. NATO MSG 159 Symposium, Ottawa, 11-12 Sept 2018.

Joshi, A., Kale, S., Chandel, S., & Pal, D.K. (2015). Likert Scale: Explored and Explained. *British Journal of Applied Science and Technology*, 7, 396-403. https://www.researchgate.net/publication/276394797_Likert_Scale_Explored_and_Explained

Kinney, G. F., & Wiruth, A. D. (1976). Practical risk analysis for safety management (pp. 1–20). Naval Weapons Center. https://apps.dtic.mil/sti/citations/ADA027189

Kokangül, A., Polat, U., and Dağsuyu, C. (2017). A new approximation for risk assessment using the AHP and Fine Kinney methodologies. *Safety Science*, Volume 91, 2017, 24-32. https://doi.org/10.1016/j.ssci.2016.07.015

Lewis, J.R. and Sauro, J. (2021). Usability and User Experience: Design and Evaluation. In *Handbook of Human Factors and Ergonomics* (eds G. Salvendy and W. Karwowski), ch. 38, 972-1015. John Wiley & Sons, Inc. https://doi.org/10.1002/9781119636113.ch38

Martin, B.C.W., Jarmasz, J., and Kirollos, R. (2021). Barriers to the implementation of the Land Vehicle Crew Training System (LVCTS): The collected wisdom of four focus group populations. DRDC.

Mcleod, S. (2023). Likert Scale Definition, Examples And Analysis. *Simply Psychology*. Likert Scale Definition, Examples and Analysis - Simply Psychology

Messick, S. (1975). The standard problem: Meaning and values in measurement and evaluation. *American Psychologist*, 30(10), 955–966. https://doi.org/10.1037/0003-066X.30.10.955

Mustafa, M. A. and Al-Bahar, J. F. (1991). Project risk assessment using the analytic hierarchy process. *IEEE Transactions on Engineering Management*, vol. 38, no. 1, 46-52, Feb. 1991, doi: 10.1109/17.65759. https://ieeexplore.ieee.org/document/65759

Olson, K. (2010). An Examination of Questionnaire Evaluation by Expert Reviewers. *Field Methods* 22:4 (2010), pp. 295–318. Sage Publications. https://digitalcommons.unl.edu/sociologyfacpub/136 https://journals.sagepub.com/doi/10.1177/1525822x10379795.

Olson, K., Lannan, K., Cumming, J., MacGillivary, H. & Richards, K. (2020). The Concerns-Based Adoption Model and Strategic Plan Evaluation: Multiple Methodologies to Understand Complex Change. *Educational Research: Theory and Practice*, 31(3), 49-58. https://files.eric.ed.gov/fulltext/EJ1274351.pdf

Polit, D.F. (2014). Getting serious about test–retest reliability: a critique of retest research and some recommendations. *Quality of Life Research* 23, 1713–1720. https://doi.org/10.1007/s11136-014-0632-9

Reid, P. (2014). Categories for barriers to adoption of instructional technologies. *Education and Information Technologies* 19:383–407. DOI 10.1007/s10639-012-9222-z. Published online: 11 November 2012. Springer Science+Business Media New York 2012.

Sireci, S.G. (1998) The Construct of Content Validity. Social Indicators Research, Vol. 45, No. 1/3, Validity Theory and the Methods Used in Validation: *Perspectives from Social and Behavioral Sciences* (Nov., 1998), pp. 83-117. https://www.jstor.org/stable/27522338

Sträub, E.T. (2009). Understanding Technology Adoption: Theory and Future Directions for Informal Learning. *Review of Educational Research*, June 2009, Vol. 79, No. 2, pp. 625-649. D01: 10.3102/0034654308325896

Taylor, S. and Todd, P.A. (1995). Understanding Information Technology Usage: A Test of Competing Models. *Information Systems Research*, Vol. 6, No. 2 (JUNE 1995), pp. 144-176.

Tenopyr, M. L. (1977). Content-construct confusion. *Personnel Psychology*, 30(1), 47–54. https://doi.org/10.1111/j.1744-6570.1977.tb02320.x

Venkatesh, V., Morris, M., Davis, G., and Davis, F. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly* Vol. 27 No. 3, pp. 425-478. https://www.academia.edu/72868491/User_Acceptance_of_Information_Technology_Toward_a_Unified_View

Wang. (2023). Perception and Behavioral Intention Toward MOOCs: Undergraduates in China. *International Review of Research in Open and Distance Learning* 24(1):22-46. https://doi.org/10.19173/irrodl.v24i1.6677

Yamashita, T. (2022). Analyzing Likert scale surveys with Rasch models. *Research Methods in Applied Linguistics*, Volume 1, Issue 3, 2022, 100022, ISSN 2772-7661. https://doi.org/10.1016/j.rmal.2022.100022

NRC.CANADA.CA • INFO@NRC-CNRC.GC.CA • 877-672-2672 •

DOCUMENT CONTROL DATA

*Security markings for the title, authors, abstract and keywords must be entered when the document is sensitive

1. ORIGINATOR (Name and address of the organization preparing the document. A DRDC Centre sponsoring a contractor's report, or tasking agency, is entered in Section 8.)

National Research Council of Canada (NRC)
1200 Montreal Road
Ottawa, Ontario K1A 0R6

2a. SECURITY MARKING (Overall security marking of the document including special supplemental markings if applicable.)

CAN UNCLASSIFIED

2b. CONTROLLED GOODS

NON-CONTROLLED GOODS
DMC A

3. TITLE (The document title and sub-title as indicated on the title page.)

Analysis of a methodology to assess barriers to instructional technology adoption

4. AUTHORS (Last name, followed by initials – ranks, titles, etc., not to be used)

Downes, S.; Emond, B.

5. DATE OF PUBLICATION (Month and year of publication of document.)	6a. NO. OF PAGES (Total pages, including Annexes, excluding DCD, covering and verso pages.)	6b. NO. OF REFS (Total references cited.)
March 2023	28	35

7. DOCUMENT CATEGORY (e.g., Scientific Report, Contract Report, Scientific Letter.)

Contract Report

8. SPONSORING CENTRE (The name and address of the department project office or laboratory sponsoring the research and development.)

DRDC – Toronto Research Centre
Defence Research and Development Canada
1133 Sheppard Avenue West
Toronto, Ontario M3K 2C9
Canada

9a. PROJECT OR GRANT NO. (If appropriate, the applicable research and development project or grant number under which the document was written. Please specify whether project or grant.)

PEOPLE_025

9b. CONTRACT NO. (If appropriate, the applicable number under which the document was written.)

NRC - National Research Council of Canada (NRC) concerning Research, Development, Test and Evaluation, Technical Services and CoOp RD

10a. DRDC PUBLICATION NUMBER (The official document number by which the document is identified by the originating activity. This number must be unique to this document.)

DRDC-RDDC-2024-C047

10b. OTHER DOCUMENT NO(s). (Any other numbers which may be assigned this document either by the originator or by the sponsor.)

11a. FUTURE DISTRIBUTION WITHIN CANADA (Approval for further dissemination of the document. Security classification must also be considered.)

Public release

11b. FUTURE DISTRIBUTION OUTSIDE CANADA (Approval for further dissemination of the document. Security classification must also be considered.)

12. KEYWORDS, DESCRIPTORS, or IDENTIFIERS (Use semi-colon as a delimiter.)

Barriers in Training Technology; Training Technologies; Traning and Education; Training and Simulation

13a. ABSTRACT (when available in the document, the English version of the abstract must be included here.)

This report examines work by DRDC to develop a model of factors that inhibit the use of learning technology in a Canadian Forces Context. The focus is to assess the background and study methodology undertaken by DRDC. It proceeds in three major states: first, a review of the literature related to technology adoption, risk management, and assessment validation; second, an examination of DRDC's pilot study and proposed wider-scale assessment from the perspective of the literature review; and third, a series of recommendations to DRDC based on the first two parts.

13b. RÉSUMÉ (when available in the document, the French version of the abstract must be included here.)

Ce rapport examine les travaux de RDDC visant à élaborer un modèle de facteurs qui entravent l'utilisation des technologies d'apprentissage dans le contexte des Forces canadiennes. L'objectif est d'évaluer le contexte et la méthodologie d'étude entreprise par RDDC. Il se déroule en trois étapes principales : premièrement, une revue de la littérature relative à l'adoption de la technologie, à la gestion des risques, et à la validation de l'évaluation ; deuxièmement, un examen de l'étude pilote de RDDC et de l'évaluation proposée à plus grande échelle du point de vue de l'analyse documentaire ; et troisièmement, une série de recommandations à RDDC basées sur les deux premières parties.