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Review of Media Analysis Methods

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DRDC TASK 11

REVIEW OF

MEDIA ANALYSIS METHODS

CONTRACT #W7719-155268

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LIST OF ACRONYMS AND DEFINITIONS

ACTIONS	Access, Costs, Teaching and Learning, Interactivity & Usability, Organization, Novelty, and Speed
ADDIE	Analysis, Design, Development, Implementation and Evaluation
CASCOIME	Cost, Accessibility, Social-political suitability, Cultural friendliness, Openness, Interactivity, Motivational
CBT	Computer Based Training
CF	Canadian Forces
CFITES	Canadian Forces Individual Training and Education System
EdO	Educational Objective
EO	Enabling Objective
FOV	Field-of-view
HSI	Human System Integration
IFE	Intermediate Feasibility Experiments
IMI	Interactive Multimedia Instruction
ISD	Integrated Systems Design
IT&E	Individual Training and Education
PADDIE+M	Planning, ADDIE, Maintenance
PO	Performance Objective
ROTI	Return on Training Investment
SAT	Systems Approach to Training
SDP	System Development Process
SECTIONS	Students, Ease of Use, Cost, Teaching functions, Interaction, Organization, Networking, Security
SME	Subject Matter Expert
SPOT	Sensory, Perceptual, Objective Task
STA	Sensory Task Analysis

TA	Technical Authority
TDO	Training Development Officers
TNA	Training Needs Analysis
TNI	Training Needs Index
ToT	Transfer of Training
VE	Virtual Environments
VIRTE	Virtual Environments and Technologies

EXECUTIVE SUMMARY

This work provides an overview of the various methods relied upon by those making decisions regarding the selection of media and level of fidelity found within training solutions. The objective of this work was to review current instructional media selection methodologies used during the instructional design process for computer and simulation based training. A survey of the literature identified approaches to the problem, and answers to questions of interest to the Technical Authority (TA) for each of the identified methods reviewed where applicable and available. Two domains were reviewed, first, Instructional System Design (ISD), concerns itself with the methods used to select the appropriate media for non-immersive training solutions, for example computer-based training. Second, human factors, Human Computer Interaction or HSI literature were reviewed, which concerns itself with higher immersive training (i.e. part task trainers, virtual environments (VEs) and high fidelity environments (live, virtual and constructive simulation).

The review of the ISD literature, training media selection methods, included U.S. and Canadian defense sector methods and six additional non-defense methods. The review included an analysis of the level of specificity and evidence for validity for each method. None of the methods reviewed were rated as having a high level of both, specificity or validity. Upon review, there seems to be no empirically validated theory or process that supports media selection. Models described in this report can help guide users by providing questions and criteria to consider while making decisions about media and instruction; however, they have yet to be empirically validated. The actual decision making process may be informed by the criteria and associated data, but the analyses are not prescriptive in nature and in the end, the decision is left to the designer. The final media selection decision across all methods reviewed does not seem to be based on any media selection method in isolation, but driven by a combination of intuition, SME experience, and the data collected based on the questions considered in the model, framework or method.

Based on the review, the existing media selection methods seem insufficient when used on their own for making decisions about which media to use for a particular result. A combination of methods may be the best solution and the methods selected would depend on the context and complexity of the environment to be designed. In addition, research reviewed suggests that other aspects such as the learner goals and objectives, subject matter, age, skill level, fidelity of technology, and cognitive functions to be supported, may all have a significant influence on the outcome of the media selected and implemented and not included in current methods.

When selecting the appropriate level of fidelity in an immersive or interactive system, practitioners may not be able to rely on the media selection methods that are used for the design of less immersive systems. This is because the level of detail regarding the components and the physical, functional and psychological factors related to fidelity are excluded from these methods. Therefore, two methods for selecting the appropriate level of fidelity for immersive environments were reviewed. It is concluded that either method could be followed when

selecting the appropriate level of fidelity, as the focus of both is on identifying the requirements up front that will support the training objectives.

Leaders in both fields seem to be cautious to support any one method as they are not ***empirically*** deemed usable, practical, and evidence-based as of yet. It can be argued that the existing media selection methods reviewed seem insufficient when used in isolation for making decisions about which media to select. Elements from a combination of methods may be best suited.

1 INTRODUCTION

This document is a report for Project W7719-155268/001/TOR Task 11 - *Top-Down Training Analysis and Media Methods Analysis Review.* Within the Statement of Work there were two main tasks requested; Task 6.2; *Derive Training Requirements from Royal Canadian Airpower Core Role, and* Task 6.3; *Review Media Methods Analysis Methods.* This particular report presents the results of the work that has been carried out to support Task 6.3; *Review Media Methods Analysis Methods.* Document # 114118-002-01 provides the work in support of Task 6.2.

1.1 Background

This work provides an overview of the various methods relied upon by those making decisions regarding the selection of media and level of fidelity found within training solutions. Upon review of the literature and discussions with Subject Matter Experts (SMEs), this area of research is particularly challenging for two reasons. First, there is very little literature supporting the empirical validation of Training Media Analyses and selection methods. This may be for a few reasons; 1.providing proof of validation is a time consuming and costly exercise, 1.as technology and media continuously evolve so may the methods used to select them making it difficult to validate, and 3.most methods rely significantly on SMEs subjective, albeit informed, final decisions regardless of the rigor of the analysis. Second, there is a significant disconnect in the literature as this field crosses two distinct domains; the first domain encompasses the traditional “school house and” less-immersive training and the second domain rests within human factors or human system integration (HSI).

The first domain, referred to as Instructional System Design (ISD), includes literature regarding the methods used to select the appropriate media for non-immersive training solutions, for example computer-based training. The more immersive the training tends to be (i.e., part task trainers, virtual environments (VEs) and high fidelity environments (live, virtual and constructive simulation) the more likely the research resides within the second domain, referred to as human factors, Human Computer Interaction or HSI. The two domains are reviewed separately within this report and can be found in Section 4 and 5, respectively.

1.2 Objective

The objective of this work is to review current instructional media selection methodologies used during the instructional design process. This includes, to a certain degree, methods to determine the required component fidelity regarding simulation (e.g., part-task trainers, full flight simulators) as well. A survey of the literature identifies approaches to the problem, and answers to questions of interest to the Technical Authority (TA) for each of the identified methods reviewed where applicable and available. These questions include:

- What information and analysis is required to use the method and is additional theory development or data collection required to use the method?

- To what level of specificity is the method able to identify the media required?
- To what extent has the model been validated?

1.3 Scope

This document is organized into the following sections:

- Section 1. Introduction: Describes the background to this work and the objectives for this document.
- Section 2. Design Processes: Describes at a high level the process typically followed to design a training environment.
- Section 3. Media: Defines and describes the various media used in instructional design and simulation to meet training requirements.
- Section 4. Instructional Media Selection: Literature review of the various methods and frameworks relied upon to select the appropriate media to meet training requirements.
- Section 5. Simulation and Level of Fidelity: Literature review of the various methods and frameworks relied upon to select the appropriate level of fidelity used to meet training requirements within the field of simulation.
- Section 6.Summary and Conclusion: Summarizes the review completed and states any recommendations that came forward upon review.
- Section 7: References.
- Appendix A: CASCOIME model media evaluation chart

2 DESIGN PROCESSES

The focus of this report is how to ‘choose’ the appropriate medium that provides the most effective learning environment, not how to ‘design’ the system. However, it is important to understand where within the instructional systems design process media selection rests and how then it may interact with other components within the process. Therefore, this section provides a brief overview of the entire ISD process, which includes the media selection process, to ground the reader and prepare for a deeper dive into the media selection component of the process.

There is not one single agreed upon standard for designing instructional systems; however, there are two prominent design processes found in the literature and in practice. The first is the ADDIE (**A**nalysis, **D**esign, **D**evelopment, **I**mplementation and **E**valuation) Model, and the other is the Systems Development Process (SDP).

The two processes can be distinguished by the level of interactivity, or what is referred to as the Interactive Multimedia Instruction (IMI) levels 1 through 4 (Figure 2-1). Levels one through three ranges from passive to complex student participation and is associated with a traditional classroom setting (e.g., Computer-based training; CBT), whereas IMI level four is associated with real-time participation within life-like virtual or real environments (e.g., full flight simulator). This report groups IMI Levels into two distinct categories; IMI levels 1-3 as one group, and Level 4 separately, as each category relies on different research domains, methods, processes, models and frameworks for their design and development.

LEVEL	DESCRIPTION
Level 1 - Passive.	The student acts solely as a receiver of information.
Level 2 - Limited participation.	The student makes simple responses to instructional cues.
Level 3 - Complex participation.	The student makes a variety of responses using varied techniques in response to instructional cues.
Level 4 - Real-time participation.	The student is directly involved in a life-like set of complex cues and responses.

Figure 2-1: Levels of Interactivity (IMI Levels 1-4), (from MIL-HDBK-29612-3, 1999)

Upon review of the literature and discussions with domain experts, it is inferred that the design of IMI levels 1-3 rely on the ADDIE Model. ADDIE is associated with classroom-based, or self-paced, instructional training solutions. Whereas higher fidelity training systems such as full flight simulators (IMI Level 4), rely on the engineering based SDP. Note that the ADDIE is modeled after a Systems Approach to Training (SAT) however, the focus of each process or model plays to the context for which they were designed. Sections 2.1 and 2.2 provide an overview of the ADDIE and System Design processes, respectively.

2.1 ADDIE

ADDIE is a conceptual framework[1] (Bichelmeyer, 2005; Molenda, 2003), used to describe the method relied upon to develop performance support tools, instructional systems and performance support tools. Upon our own review, and according to Molenda (2003, p. 35), the ADDIE process and term does not appear to be referenced by an original author but has “evolved informally through oral tradition”. There is reference to the idea that it was developed in the 1970s for the US Army by Florida State University’s Center for Educational Technology[2]. The ADDIE model represents a range of models that share similar processes resulting in an instructional and is accepted and relied upon within militaries (Department of National Defence, 1999b; Department of the Army, 2015) and learning institutions around the world (Bates, 2015b; Dick, Carey, & Carey, 2006; Gustafson & Branch, 2002; Holden, 2015; Peterson, 2003).

2.1.1 Overview of the ADDIE Model

In the ADDIE model, the training lifecycle involves the entire ‘life’ of a solution, from the initial identification of a training requirement to the point where the training solution is modified, replaced, or no longer required. Figure 2-2 provides a graphic interpretation of the ADDIE model. Within the context of the Canadian Forces (CF), the policy on Individual Training and Education (IT&E) states that the manual provided [i.e., Canadian Forces Individual Training and Education System (CFITES)] shall guide instructional design and reliably built upon the ADDIE model.

[1] The ADDIE process will be referred to as a “model” herein to be consistent with the majority of the relevant literature.
[2] https://www.trainingindustry.com/wiki/entries/addie-model.aspx., last accessed 31/05/2017

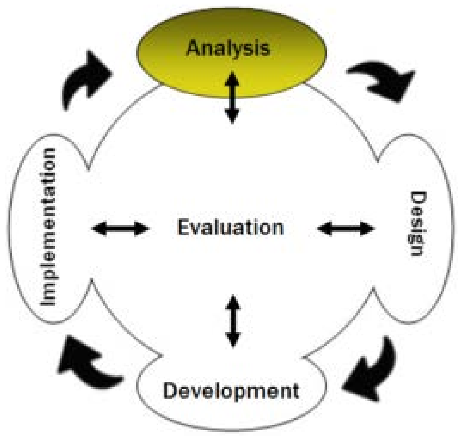

Figure 2-2: The ADDIE Model (Holden, 2015, p. 5)

The five phases in the ADDIE model include:

1. **Analysis:** In this phase of the ISD process, the designer identifies specific variables, which includes the goals and objectives of the solution or course [(Performance Objectives (PO), Educational Objectives (EdO) and Enabling Objectives (EO)], the environment, learner characteristics, prior knowledge, and the resources that are available to develop and manage the solution. The methods used to complete this analysis are varied, but can include mission and function analysis, user needs analysis, training needs analysis (TNA), target audience analysis, and job analysis.

2. **Design:** The design phase utilizes the results of the analysis phase to create detailed plans for the training solution. This includes the design of assessment tools and approaches, exercises, content, lesson plans, and creation of documentation concerning the framework and guidelines for the training solution. Of direct relevance, it is in this phase that designers select the appropriate media for content delivery. For example, the ISD may design a storyboard outlining the order of what to display via text, audio, and video. The focus of the section 4 lies within this phase – the design phase, where media selection occurs.

3. **Develop**: Based on the solution architected during the design phase, at this stage the ISD team creates and assembles the content, builds the devices, integrates additional technology, and ensures the training solution is ready for deployment through user testing.

4. **Implement**: During implementation, users are able to try the system on site. The implementation phase also includes training the instructors with respect to the course curriculum, expected learning outcomes, media used, and testing procedures.

5. **Evaluate**: The last phase of this iterative lifecycle is an evaluation of the solution and the learners' performance (e.g., retention, accuracy, transfer of training). This includes collecting feedback and data used to identify areas of improvement. These improvements are made

based on feedback for the next release or iteration of the solution. Both aspects of this evaluation (system and learner) is important because if learners are not successful, they could be deemed incompetent to perform their job and the outcome may be that the training solution must be re-evaluated and potentially redesigned if it is having a negative impact on performance.

There are numerous variations of this model, for example, the United States Navy added “P” to the beginning of ADDIE and “M” to the end to create the ‘PADDIE+M’ model. The ‘P’ refers to the planning phase (project goals, budget, and schedules) and the ‘M’ refers to maintenance (continuous improvements) (U.S. Navy, 2010). However in general there is a consensus that the original model still “guides instructional designers as they attempt to approach instructional design problems in a systematic way” (Bichelmeyer, 2005, p. 5) and can be applied iteratively with “evaluation leading to re-analysis and further design and development modifications” (Bates, 2015b, p. 140).

The ADDIE model provides a systematic process and template or structure for ISDs to rely on. According to Bates, ADDIE is associated with “good quality design, clear learning objectives, carefully structured content, controlled workloads for faculty and students, integrated media, relevant student activities, and assessment strongly tied to desired learning outcomes” (2015b, p. 117). Some ISD professionals have critiqued ADDIE and have suggested that the model can be time consuming, costly, and therefore inefficient for small-scale projects (Bates, 2015b). Additionally, some claim that ADDIE is not prescriptive in nature and lacks guidance on how to make decisions within the model. For instance, ADDIE does not provide guidelines related to decisions regarding the selection between technologies or strategies to rely on. Therefore, instructors or designers must reach beyond the ADDIE framework to make these decisions. Section 4 of this report focuses on the additional resources ISDs can rely upon.

2.2 System Development Process

ADDIE traces back to an adaptation of a systems engineering approach as it incorporates the majority of phases within the engineering lifecycle, while placing an emphasis on instructional design issues (inputs, outputs, users, etc.). The intention of this section is to provide the reader with an overview of the process(es) that are relied upon when defining requirements for a higher fidelity training system. These may include systems such as part-task training systems, virtual environments and full flight simulators. This section will provide the reader with the necessary background information referred to within Section 5.

The system analysis and development process (SDP) includes the following phases (CAE Inc., 2014):

1. **System requirements analysis:** This phase includes the activities that are required to gain an understanding of the user needs, analogous to the **A**nalysis phase in the ADDIE model. The requirements should be clear and concise enough so that each requirement corresponds to a specific element in the design of the system. This may also include experimental research, such as human factors analyses.

This phase identifies the training objectives, scenario/mission elements to be included in the training system, and an assessment of the gaps between the as-is and to-be systems (if applicable). The tasks in this phase may include end-user needs analysis via task/TNA, usability assessment, and/or human factors assessment for each component within the system (P. Muller et al., 2006; P. Muller, Cohn, & Nicholson, 2003). According to Muller et al.(P. Muller et al., 2003, p. 6) this phase may also include the identification of the sensory modality integration requirements, (i.e., visual, auditory, haptic, olfactory, kinesthetic, etc.) and how best to support these requirements from a technological standpoint (i.e. visual, auditory, haptic, olfactory, kinesthetic, etc.) and how best to support these requirements from a technological standpoint (i.e., hardware/software required). The result of the analysis can be used to understand how the students may be impacted by the design of the system and to provide evidence and traceability for the design decisions or level of fidelity selected for a particular component.

Unlike the ADDIE model where media selection is traced to the “Design” phase, the training solution level of fidelity requirements will be chosen during this phase as it is informed by the outcome of a literature review, experiment, or human factors analysis. Essentially, the analysis directly influences the design decisions made.

2. **System design:** Activities in this phase include defining the technical specifications that will meet the requirements specified in the previous phase, including the hardware and software (and all related subsystems). During this phase the various components of a training system are selected, including the level of fidelity required to meet the user requirements previously defined. Again, the level of fidelity is informed by the analyses completed in the previous phase.

3. **System development**: In this phase all design decisions are implemented, e.g., if the system is software based, the coding will take place along with validation and traceability of the code back to the design element and requirements.

4. **System testing and evaluation**: In this phase errors are detected and corrected. This includes informal testing (verifying design along the way), and formal testing (validating that the requirements are met). This phase includes an evaluation of system effectiveness and efficiency from an end-user perspective including any negative effects incurred due to system exposure , such as simulator sickness.(P. Muller et al., 2006, 2003). This phase could also include a validation of the degree to which the system meets the original training objectives (P. Muller et al., 2006, 2003).

5. **System acceptance and installation**: Prior to this phase, the system has most likely been developed and tested in a non-operational environment. Therefore, this phase ensures that the system is delivered or deployed (installed) and accepted by the client on site. System acceptance tests are conducted to validate that the system performs as intended in the operational environment.

The SDP also has associated strengths and weaknesses. The SDP not prescriptive in nature and should be tailored to the specific environment and domain to accommodate the individual needs. Some strengths of the SDP include that it provides systematic control over the entire lifecycle which for larger projects could provide a significant return on investment, ensures that there is well defined user input, provides detailed steps to follow while affording customization, and provides development and design standards. Some weaknesses include an increase in time to develop along with associated up-front costs, system is required to be defined from the beginning, and it can be difficult to estimate the cost.[3]

[3] https://en.wikibooks.org/wiki/Introduction_to_Software_Engineering/Process/Life_Cycle#Strengths_and_weaknesses, last accessed 5/31/2017.

3 MEDIA

This section provides the reader with more detailed descriptions of the various levels of interactive media (IMI Levels 1-4) and each medium (as described in MIL-HDBK-29612-3, 1999) available to practitioners. The intention of this chapter is to ensure all readers agree on the definitions of the various IMI level and available media. Familiarization with each medium will ensure the reader is knowledgeable of the various forms a designer may select prior to presenting “how to select” the appropriate media via the various frameworks and models.

According to the CFITES: Design of Instructional Programmes (1999a, p. 15) ‘medium’ refers to the “means of delivering instructional activities to the learner” and which can include text books, computer based content, and simulators. Within the literature, the terms ‘media’ and ‘technology’ are sometimes used interchangeably. Bates (2015b) argues that these two terms should be understood separately, particularly within the context of selection. Technology, in the context of education, is defined as a tool used to support pedagogy (e.g., computers, books, networks) however, the technology itself does not contain any “meaning.” The basic function of the word ‘technology’ is to identify a “general tool” and the word ‘media’ to identify the “means of communication”.

3.1 List of Media

A list of the various media and definitions have been extracted from CFITES Manual of Individual Training and Education (Department of National Defence, 1999a, p. E1, 1999b). This list also includes associated benefits and limitations of each medium, which includes:

- **Instructor led:** Activities conducted in person in a classroom setting.
- **Printed material:** Text or graphics used to provide content and learner with activities.
- **Video:** Moving images including sound.
- **Computer (or web) Based Training (CBT):** Computer program including text, and graphics via a local computer or through the web.
- **Multimedia:** Computer based training that also includes audio, animation, and video.
- **Tele/computer/video conference:** Digital voice based communications linked by telephone, video, or computer.
- **Audio graphics:** Teleconference that includes two-way transmission of graphics and sound in real time.
- **Models/mock ups:** Three-dimensional devices used to represent the real system.

- **Simulator:** Dynamic device representing a system that learners can interact with in a realistic manner.

- **Real equipment:** Actual equipment used for training purposes.

Note that limitations and benefits associated with each type of media can be found in the CFITES: Design of Instructional Programmes and MIL-HDBK-29612-2 (Department of National Defence, 1999a, 1999b, respectively) as well as other non-military references (Bates, 2015b).

3.2 IMI Levels

Based on the literature reviewed, there seems to be an “invisible” line drawn between IMI Level 3 (audio, graphics and above) and IMI Level 4 (models/mock ups and simulators). The media selection models reviewed in this report can be found in the training and education domain and refer mostly to IMI Levels 1 through 3 as solutions. As the solution moves from IMI Level 3 to Level 4, the literature shifts from education into Human Factors, Psychology, Human Computer Interaction, and Engineering domains. This most likely occurs because of the level of complexity and cost when moving to a simulated environment versus a CBT environment and the associated effects it may have on the learner and their experience as well as the organization.

The way in which the selected components relate to higher fidelity models and simulators is less documented as a process, when compared to media selection for CBTs. The processes for simulation and the selection for specific levels of fidelity are found to be more academic in nature, and specific to certain research projects (R. K. Champney, Carroll, & Surpris, 2014; Milham, Bell-Carroll, Stanney, & Becker, 2009; P. Muller et al., 2006, 2003; Padron, Champney, & Carroll, 2016). Therefore, Section 4 provides a review of relevant media selection models for IMI Levels 1-3, and Section 5 provides a review of methods used to select the level of fidelity.

4 INSTRUCTIONAL MEDIA SELECTION

During the course of investigation,[4] it became clear that only a handful of models and frameworks are relied upon to select the most appropriate media for instruction. Seven models were selected and reviewed based on relevance, conversations with the TA and SMEs and include the following sections and models:

1. Section 4.1: Defense related guidance (Department of National Defence, 1999a; MIL-HDBK-29612-3, 1999)
2. Section 4.2: ACTIONS (Bates, 1995)
3. Section 4.3: SECTIONS (Bates, 2015b; Bates & Poole, 2003)
4. Section 4.4: CASCOIME (Patsula, 2002)
5. Section 4.5: Huddlestone and Pike's 7 Key decision factors for selecting e-learning (Huddlestone & Pike, 2008)
6. Section 4.6: Koumi's Media Selection and Deployment Guidelines (J. Koumi, 2006b)
7. Section 4.7: Sugrue and Clark's Media Selection for Training (Sugrue & Clark, 2000)

The selected models and frameworks provide guidelines for media selection; however, there is a general lack of literature regarding whether the process has been validated and how, or whether additional theory development or data collection is required. Section 4.8 discusses the lack of empirical evidence that was uncovered from various sources, as we felt this was a significant gap and required a deeper discussion that was not method dependent. Regardless of the lack of true empirical evidence for media selection, each model was reviewed for the following information:

- What information and analysis is required to use the method?
- To what level of specificity is the method able to specify the media required?
  - The "level of specificity", for the sake of clarity and consistency, is defined as the "careful thoroughness of detail" and will be rated as high, medium or low.
    - **High level of specificity**: a model or framework that provides enough details regarding the information required that the user does not have to revert to other resources or presumptions. Criteria or questions are rated or prioritized based on

[4] The "investigation" for the content of this statement includes the literature review and numerous discussions with SMEs at CAE, Canadian Defense, and within industry.

research or evidence. At the highest end of this category, the framework provides a clear, effective and efficient assessment aid or tool used by the designer.

- **Medium level of specificity**: a model or framework that provides adequate details regarding the information required, but the user may have to revert to other resources or presumptions about the information required. Criteria or questions may be rated or prioritized. If an assessment tool is provided, the tool may be difficult to use or the information may not be complete enough to be useful when making media selection decisions.

- **Low level of specificity:** a framework that only provides high level guidelines and lacks further details regarding the information required. The user will require other resources and will need to make vast assumptions about the information required. Data required is not prioritization or rated and an assessment tool is not provided.

- To what extent has the model been validated?
  - A distinction can be made between internal and external validity. Internal validity can refer to the model's reliability between users (i.e. do users rely on the methods consistently between each other and between different solutions?). Whereas external validity focuses on the effectiveness of the models' outcome (the solution) on the learner and other stakeholders. Did the media selection model ensure that the solution met all requirements?
  - The levels of internal and external validity for the sake of clarity and consistency, will be rated with the following scale and criteria:
    - None – there was no evidence provided for external or internal validity. This is not to say it is not a valid method, or even that evidence does not exist for proof of validity, but merely that none was located/reviewed.
    - Low – minor effort made to provide evidence of internal or external validity.
    - Medium – evidence of internal or external validity provided.
    - High – significant evidence of internal and external validity.

4.1 Defense Guidelines

The United States (MIL-HDBK-29612-3, 1999) and Canadian Militaries (Department of National Defence, 1999a) provide guidelines for media selection. Each are discussed in brief in this section to provide an overview to the depth of guidance, or lack thereof, for media selection.

4.1.1 U.S. Handbooks: MIL-HDBK-29612-3 and MIL-HDBK-29612-2 Section 7

Section 7 of MIL-HDBK-29612-2 Instructional Systems Development/Systems Approach to Training and Education provides guidance for the selection of media. The output of media selection identifies the appropriate media for supporting identified Learning Objectives (LOs).

Section 4.9 of (MIL-HDBK-29612-3, 1999) Development of Interactive Multimedia Instruction (IMI) provides a high level overview of the media selection process, and refers to (MIL-HDBK-29612-2, 1999) section 7 for further details.

According to MIL-HDBK-29612-3, media selection is a four step process and is conducted as follows (1999, p. 10):

- Identify sensory stimulus requirements for each learning objective,
- Identify sensory stimulus features for all available media,
- Match the sensory stimulus requirements with the sensory stimulus features to identify a candidate list of media, and
- Select the delivery media based on resource constraints, classroom logistics, and all other relevant considerations.

In addition, Section 7.10 of MIL-HDBK-29612-2 (Department of National Defence, 1999b, pp. 85–98) provides with a list of media, defined as a “means used to give information to the students”(Department of National Defence, 1999b, p. 86) and examples of each. Affordances and limitations are listed for each media type in Section 7.10.3.

These include:

- Printed materials;
- Overhead transparencies;
- Audio tape recordings;
- 35mm Slide Series;
- Multimedia presentations;
- Interactive courseware;
- Video and Film;
- Part-task trainers; and

- Simulators.

The handbook also provides guidance regarding attributes that should be considered, namely the enterprise (what is initiating the LO), student schemas (students' level of knowledge), meta-skills (cognitive strategies relied on to process new information) and the students' level of experience (i.e., novice, intermediate, expert). Six general guidelines are provided to the designer and request that media is selected so that it:

- does not conflict with the specific training environment;
- effectively supports the LOs at the appropriate learning levels;
- supports the training strategy;
- allows individualization of training when appropriate;
- considers time and dollar resources; and
- is effective and cost-efficient.

In a slightly more prescriptive way, the handbook then suggests that the sensory stimulus be analyzed for each LO, suggesting that each LO has a requirement for sensory stimuli in order to effectively communicate a change in activity. A table of 30 sensory stimuli are provided and categorized by sense; visual, auditory, affective, tactile, and olfactory. The handbook suggests the following process associated with selection of media and appropriate sensory stimuli be followed:

- assign to each LO the set of sensory stimuli required;
- assign to each media a set of sensory stimuli that it supports as media features; and
- match the sets of sensory stimulus requirements with the list of media features.

The result of this three-step process is a list of media requirements used to select the appropriate media. The media may be packaged in various forms, for example, a given LO might require a motion visual with accompanying sound. This set of media could be formatted as a film, a video, or a computer image; the method does not prescribe to that level of detail. Therefore, the final decision regarding media selection needs to consider the learning context in which it is being used, and the entire set of LOs in order to create a feasible holistic solution.

After the media is selected, an analysis should be conducted to determine if the selected media is practical, affordable, and supportable. The handbook provides a job-aid to guide the user to determine feasibility. Note that there is no empirical evidence provided regarding the process and guidance within this handbook.

4.1.2 Canada: Canadian Forces Individual Training and Education

Volume 4 of CFITES (Department of National Defence, 1999a, pp. 15–18) provides high level guidance to aid in identifying the appropriate media . Section 3 of the manual provides a list of media and definitions associated with each, as well as listing characteristics of media associated with the inputs that are essential to learning: presentation, application, feedback, interaction and testing (1999a, p. 15). Organization and cost related constraints are identified to ensure the medium requested is feasible. The manual also provides general guidelines regarding issues to consider that are specific to the subject matter being taught. In general, the guidance provided in CFITES manual is not prescriptive and provides guidance only.

CFITES, compared to the U.S. handbook, is less structured. According to an SME, Training Development Officers (TDOs) have completed some improvements to the manual and associated processes; however, these changes have yet to be included in CFITES manuals, and may be isolated at the unit level. Provision of systematic guidance when selecting media beyond the ones provided in CFITES will ensure the development of effective learning contexts. The following sections provide an overview of non-defense domain models and frameworks, starting with the ACTIONS model.

4.2 ACTIONS Model

The ACTIONS model, developed by Bates in 1995, is a method used to evaluate learning technologies. ACTIONS is heavily based on the ADDIE systems approach, and designed with an emphasis on open and distant education.[5] ACTIONS follows Tony Bates' previous work related to the assessment of technologies used for learning. In general, the model provides a set of seven questions to be considered when selecting media. Note that this model was developed originally to support the design and delivery of distance education, although there is no apparent reason to restrict it to distance education environments. The author gives attention to the educational issues, as well as organizational ones. This model seems easy to follow and is sufficiently flexible to account for new technology as it emerges.

4.2.1 Description

'ACTIONS' is an acronym standing for the elements that Bates believes should be considered when selecting media; **A**ccess, **C**osts, **T**eaching and Learning, **I**nteractivity & Usability, **O**rganization, **N**ovelty, and **S**peed. Bates considers all seven items vital when developing new training solutions, particularly when they are novel and the technology and learner performance associated with them have yet to be validated. Bates (1995) also provides guidance regarding the use of novel technology for the sheer reason that it is novel, suggests that the utilization of carefully considered technology is critical in the design of an effective solution, and stresses the benefits of using "tried and true" technology, interwoven with the new.

[5] https://insdsg619-sp10.wikispaces.com/Bates+Model, last accessed 5/31/2017.

4.2.2 Information and Analysis Required

Information required to use this method is related to the questions posed within each section of the model. The analysis phase (i.e., task analysis or TNA) that should be completed prior to media selection, provides a significant amount of data that can be reused when applying this model, but perhaps viewed from a slightly different perspective, i.e., focus is on the specific medium, not the learner per se. In general, the user of the ACTIONS model will need to acquire information regarding each media type and identify.[6]

- how accessible it may be to the learner;
- the associated costs of acquiring the medium versus other alternatives;
- the instructional requirements and whether the medium supports it best;
- the level of interactivity required and how easy it is to learn and use;
- organizational constraints regarding acceptance and integration;
- technical strengths and weaknesses; and
- how flexible and modular the technology is when new content needs to be added.

Table 4-1 provides the specific questions posed for each element in the ACTIONS model.

Table 4-1: Bates ACTIONS Model Criteria and Questions Posed (Bates, 1995)

Criterion	Question
Access	• How accessible is the media/technology to the students? • How flexible is the technology for the group?
Costs	• What is the cost structure for the technology? • What is the unit cost per student? • What are the opportunity costs vs other technology choices?
Teaching & Learning	• What kinds of learning are required? • What instructional approaches will best meet the needs identified? • What are the best technologies for supporting teaching and learning in this environment? • Can the content be adapted to the technology? • What skills does the technology develop?

[6] Note that the information in this section was taken directly from Bates (1995)

Criterion	Question
Interactivity & Usability	• What kind of interaction does this technology enable? (I.e., synchronous vs asynchronous) • How easy is it for the students and instructors to learn?
Organization	• What are the organizational and institutional issues and requirements to provide stability and support? • What are the constraints to using the technology successfully within the institution? • What chances will need to be made to incorporate the technology?
Novelty	• How new is the technology? • What are its technical capabilities?
Speed	• How quickly can courses be created and distributed with this technology? • How quickly can the content be changed?

The analysis can begin once the data is acquired by answering the above question set. Bates (1995, pp. 59–60) argues that this decision is not going to be driven by hard and fast rules or algorithms, and that the final selection of media should be based on a combination of intuition, SME experience, and the data collected based on the questions in the ACTIONS model. The author believes that given the appropriate framework for analysis, as presented, the user has to come to their own final decisions and conclusions regarding the best combination of media to deliver the training solution. He suggests that media selection is a combination of art and science.

4.2.3 Level of Specificity

The level of specificity is rated ‘medium’. There is a significant amount of information to be considered within each criterion. This is not a prescriptive process in nature and does not provide any guidance regarding specifics in the selection of technology. Rather it provides important factors to be considered by decision makers. Note that the questions are not rated or prioritized in any way for the user to be able to rate or deem one datum more important over others, and an assessment tool was not found to be associated with this framework.

4.2.4 Evidence for Validity

Evidence for validity is rated ‘medium’. There was an attempt made to provide some evidence of validity. According to Bates & Poole (2003) the ACTIONS model has been applied by a number of different users who deem it as “practical and useful” (p.78). The authors listed a distributed learning course used by the College of the Rockies[7] but no other sources. Although this does not provide evidence of validity, Bates reviewed recent publications and claims that despite

[7] http://www.cotr.bc.ca/cdc/Distributed_Learning.htm

rapid developments in media and technology over the last 20 years, his ACTIONS model (1995) is one of the major models being applied as is or with modifications (e.g. Koumi, 2006a).

In 2007, a study was conducted to examine the criteria that had a high impact on media selection (Zaied, 2007). Three groups (faculty, Information Technology specialists and students) were provided with 19 criteria and were asked to evaluate the criteria presented. The criteria were then weighted according to impact, resulting in seven criteria deemed to have a high impact on media selection, and Bates ACTIONS model contains four of the seven criteria. Although this is not evidence for validity, one can argue that most of the criteria selected for analysis may have a high impact according to stakeholders.

4.3 SECTIONS Model

In 2003, Bates created the SECTIONS model, a modified ACTIONS model, for use of media selection in campus-based as well as distance education (Bates and Poole, 2003). It is apparent that this model, compared to the ACTIONS model, takes a more holistic approach and places an emphasis on operational and contextual issues. According to its author, the model is "based on research, stood the test of time and has been found to be practical" (Bates, 2015b, p. 266). SECTIONS has the following characteristics (Bates, 2015b, p. 266):

- works in a wide variety of learning contexts;
- allows decisions to be taken at both a strategic, institution-wide level, and at a tactical, instructional level;
- gives equal attention to educational and operational issues;
- identifies critical differences between different media and technologies, thus enabling an appropriate mix to be chosen for any given context;
- easily understood, pragmatic and cost-effective; and
- accommodates new developments in technology.

4.3.1 Description

SECTIONS stands for, **S**tudents, **E**ase of Use, **C**ost, **T**eaching functions, **I**nteraction, **O**rganization, **N**etworking, **S**ecurity. Unlike the original ACTIONS model, criteria are listed in descending order of importance, with students being the most imperative. Section 4.3.2 provides a brief description of each criterion in terms of the information required to capture and associated analysis.

4.3.2 Information and Analysis Required

The process requires the designer to follow the steps below:

1. **Define** what needs to be accomplished. The focus here is on providing an effective learning environment that supports the learners' needs. For example, what do you really want your students to learn? How could you[8] make your course more effective? What technology are you thinking of using to support this goal?

2. **Assess** the chosen technology against the questions posed within each criterion (see Figure for an example of an assessment tool used that accompanies this phase):

   Student:

   - Demographics (e.g., how diverse are the students in terms of knowledge, skills and study styles?);
   - Access (e.g., institutional policies regarding access to technology, compatibility with other devices, home or classroom); and
   - Individual learning differences (e.g., does it support various learning styles?).

The tool/platform I am assessing: ______________________________

Date:______________________________

	Questions to Ask…	Y	N	N/A	Importance (high,med,low)	I need to consider…
S	Students					
	• Are transferrable skills being developed? • Does the technology allow for an appropriate degree of openness to the community beyond registered course participants? • Can students show their work via web link (url)?					

Figure 4-1: Example of Bates and Poole's Assessment Tool used to accompany the SECTIONS Model regarding the Assessment of "Student" Related Criteria.

   Ease of Use:

   - Orientation (e.g., novice students should be able to learn tool within 20 minutes);
   - Interface design (e.g., intuitive and easy to use); and
   - Reliability (should be a reliable and robust tool).

[8] Refer to https://wiki.ubc.ca/images/1/19/SECTIONS_Framework.pdf for an assessment aid.

Cost:

- This criterion includes the costs associated with development of the actual media (e.g., production costs, instructor time to develop and produce material), delivery and the time and support required, maintenance costs including content updates and technological updates, and overhead costs[9] (e.g., infrastructure or overhead costs of licensing the system).

- According to the SECTIONS model, the primary cost drivers are:

  - Development and production of materials;

  - Delivery of materials;

  - Number of students/scalability;

  - Experience of an instructor working with the medium; and

  - Whether the instructor develops materials alone (self-development) or works with professionals.

Teaching and Media Selection:

- Design decisions: These decisions are critical to ensuring the selected technology is effective. Once the media is selected, focus on design decisions by attending to Mayer's 12 principles of multimedia design based on cognitive processing (Mayer, 2009). These principles include items such as coherence, temporal and spatial contiguity, pre-training, modality, customization, etc.

Interaction:

- The level of interaction is an important criterion from the perspective of how the medium and technology will support the various ways learners can interact with the content (e.g., with learning materials, with the teacher, and with other students). The author (Bates, 2015b) provides three dimensions of interactivity regarding how active or passive the user response needs to be. The dimensions to consider when analyzing this criterion are inherent, designed and user-generated levels of interactivity.

[9] Note that costs associated with overhead are typically shared services across multiple courses and may not need to be factored into the decision on what media to use.

Organizational Issues:

- Organizational issues will have a significant influence on the media selected by the designer or teacher. Issues include the organizations' willingness and readiness to adopt the technology, or the current supported technology available to the teachers.

Networking:

- The importance placed on the ability for students to network (e.g., social media, learning groups) outside of the course boundaries will influence the technology selected.

Security and Privacy:

- Requirements surrounding security will influence the media and technology required to support learners. Students should remain protected from privacy issues, harassment and bullying, and therefore the environment may need to be controlled. From a security standpoint, institutions should be wary of cloud-based services as data may be hosted out of country and therefore may afford access to other countries.

3. **Implement** the media while engaging stakeholders to assess their impressions and keep the decision iterative. This will help decision makers determine whether the media is worth pursuing and what additional considerations are required to improve the solution.

4. **Refine** the approach while considering the implementation. Consider what worked and did not work and create a plan to make changes.

Bates also provides a useful high-level summary of 12 rules that he believes are prudent in using and selecting educational media for training. Below are a selected few that are relevant to media selection:

- designing effective learning experience requires instructional designers who understand the technology;
- each medium has its own idiom and grammar to follow for professional production;
- educational technologies are flexible and can be used in a variety of ways limited only to human imagination and creativity;
- there is no "super-technology";
- make all mediums (face-to-face, print, audio, video, interactive multimedia) available to the learners; and
- technology is not the question, decide what the students need to learn through the use of technology.

Authors point out that the process of media selection is not mechanical or "scientific". There are many different factors to consider, and the decisions are context dependent. Although not explicit in the process, if followed correctly, access to and inclusion of the stakeholders during the initial TNA should identify organizational priorities and constraints. This should be the input for criterion weighting and aid in decision-making. The process primarily sensitizes the practitioner to the key factors to consider during the iterative design process and decision making during course development and design.

4.3.3 Level of Specificity

The level of specificity is rated as ‘high’. The SECTIONS model provides a significant amount of detail within each criterion to be evaluated, however Bates suggests that once the data is collected against each criterion, users rely on an inductive decision making approach. Bates believes that the process of media selection cannot be prescriptive. Instead, he suggests that that a subjective, “gut feeling” should be the starting point that drives an a-priori hypothesis about specific media that may support the training solution in the best way possible, and while keeping all options open, ISD’s start to collect the data associated with each criterion against the media that they “feel” will be the best fit. Therefore, the decision for each media selected in the end is supported by the data collected across all criteria ***as well as*** the designers “insight and experience”.

There are tools associated with each phase of Bates framework, and the user should not have to rely on external resources to conduct the analysis. Note that the framework does not rate the criteria but states that the ISD should rely on their own experience, skill and insight while making the final decision – that the data and analysis should be one of many factors when selecting media.

4.3.4 Evidence for Validity

Evidence for validity is rated as ‘medium’, only because this is a further development and refinement of the original ACTIONS model, also rated as medium. Note that no further evidence or literature was found regarding SECTIONS validity. Although the authors state that the model is “based on research, stood the test of time and has been found to be practical” (Bates, 2015b, p. 266), there seems to be no available evidence provided to support this statement.

4.4 CASCOIME Model

4.4.1 Description

The CASCOIME model, developed by Patsula (2002), includes some of the same criteria found in the ACTIONS and SECTIONS models, but adds additional criteria. Patsula focuses on items related to different cultures and the impact technology may have, such as socio-political suitability and cultural friendliness. This model focuses on media selection specifically for distance education that needs to meet the requirements of minority groups and developing regions; however, it seems to be easily applicable to all types of solutions.

4.4.2 Information and Analysis Required

CASCOIME outlines eight guidelines, presented in descending order of importance, for evaluating and selecting new media or technology. However, these guidelines are useful for media selection for most educational solutions. Below are the eight guidelines and associated questions to consider [taken from (Patsula, 2002)]:

- **Cost:** Is the medium cost effective (based on fixed, variable and course material costs) and does the organization have the infrastructure currently in place to support the medium?
- **Accessibility:** Is the medium affordable by the users, can it be accessed by the user group and it is usable?
- **Social-Political Suitability:** Is the medium socially and politically suitable?
- **Cultural Friendliness**: Is the medium culturally appropriate in terms of the traditional way of learning and cultural norms?
- **Openness/Flexibility:** Is the medium flexible, foster collaboration and support various ways of learning?
- **Interactivity:** Is the medium interactive and support learner-learner and learner-instructor interaction? Does it support feedback?
- **Motivational Value:** Does the use of the medium foster motivation, and is it encouraging to use?
- **Effectiveness:** Is the medium effective and efficient?

Figure 4-2 provides a chart that accompanies the framework. This chart provides the eight attributes for users to consider when evaluating media, listed in relative order of importance. The “Value” box allows Users can increase the importance of key criteria using the “value box” (shown in Figure 4-2). For example, ‘access’ can be tagged with a higher value if deemed more important when compared to cost because of contextual factors in a particular assessment. Although these valuation assignments are somewhat subjective, they do provide a more functional tool than if all criteria were valued equal. Each criterion is assigned a number from one to ten in the “Rating” box. The “Score” for the attribute is determined by multiplying the “Value” and the “Rating.”

CASCOIME guidelines may not provide practitioners with easy answers to the selection of media, but will enable them with questions that will help to point them in the right direction.

CASCOIME Media Evaluation Chart: *Eight Practical Guidelines for Selecting Media in an International Setting*								
			Media 1		Media 2		Media 3	
	Factor	**Value**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
1	**Cost -** Is the medium cost effective? Can it reach a wide enough audience? What technology infrastructure is currently available?							
2	**Accessibility –** Is the medium accessible? Does it facilitate distribution? Is it convenient to use? Is it user-friendly?							
3	**Social-Political Suitability –** Is the medium socially and politically suitable? Does its use coincide with social and political agendas of governing bodies?							

Figure 4-2: Excerpt from Patsula's (2002) Assessment Aid used to compare Attributes across Multiple Media Types

4.4.3 Level of Specificity

The CASCOIME framework level of specificity is rated as 'medium'. Although there is not a significant amount of information considered within each criterion, nor is the process prescriptive, there is significant quantitative guidance regarding assessment and comparative evaluation. In addition, the criteria are prioritized in order of importance, but provide users with the flexibility to re-prioritise based on contextual factors identified in the original TNA.

4.4.4 Evidence for Validity

Evidence for validity is rated as 'none'. CASCOIME is a practical and usable solution and may help inform practitioners as to what is important to consider regarding media selection, however no proof of validity was found.

4.5 Huddlestone & Pike's 7 Key Factors Framework for e-Learning

4.5.1 Description

A review of media selection theories, provided by Huddlestone and Pike (2008), identified seven key factors that should drive the selection of e-learning (i.e. any training delivered electronically, e.g., web and computer-based, available on demand). These factors include:

- learning task;
- media attributes;
- grouping strategy;

- learning context;
- learner characteristics;
- instructional management; and
- cost effectiveness.

Huddlestone and Pike's guidance enables the practitioner to assess how suitable e-learning is to a specific learning task and provides a framework to analyze the impact (organizationally and contextually) it may have holistically. When designing learning, one first needs to identify who, what, why, when, etc. (read TNA). Part of this is the Task Analysis, to understanding "what" is to be learned by "whom". This forms the basis of any follow-on analysis. Although the focus of this method is e-learning, it can be generalized and applied to any form of training since it includes the attributes of specific media to be considered, and how they relate to the characteristics of each learning task included in the training solution.

The authors suggest that media selection does not exist in a vacuum, but that there are factors that reside outside the scope of media selection that should be taken into account that are interrelated with media selection. Therefore, this holistic approach to media selection includes a framework that considers the surrounding factors influencing media selection. For example, when referring to Figure 4-3, instructional management, which includes issues surrounding delivery and management plays a role in this framework, among others. Delivery issues refer to content delivery methods (i.e., individually or in a group), management issues (i.e., management regarding the resources such as scheduling) and the system itself (e.g., evaluation of effectiveness).

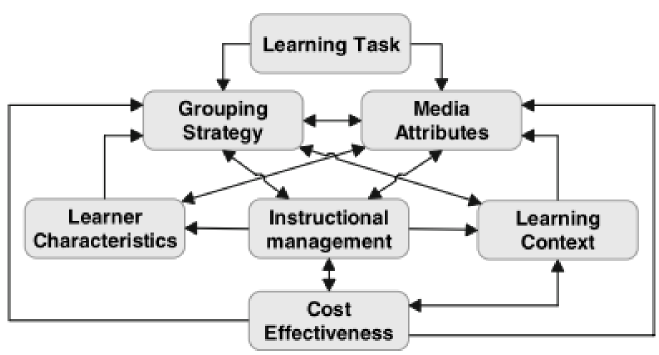

Figure 4-3: Interrelation of Factors that may affect Media Selection (Huddlestone & Pike, 2008, p. 244, Figure 4)

4.5.2 Information and Analysis Required

Information required to select media can be determined through strategic and tactical decisions in this framework. Strategic decisions are those related to available media types, whereas tactical are made by designers as part of the training options analysis phase of the instructional design process. The seven factors listed in this model relate to tactical decisions, however the interactions between some of the factors will lend themselves to more organizationally related strategic decisions. Note that factors related to organisational issues are not included as the authors felt that these relate more to the design of the system as a whole, not the selection of appropriate media. They did include cost effectiveness, which is more of an organizational concern, but they felt that it was necessary to include as it could significantly impact the selection process. The authors present the seven factors exemplified by specific questions (taken directly from Huddlestone & Pike, 2008, p. 239):

1. Learning task considerations—is the learning task suitable for e-learning?

2. Media attributes—does e-learning support the necessary media attributes and interactions required for the instruction?

3. Grouping strategy considerations—is the learning task capable of being handled through individualised instruction?

4. Learning context and practical considerations—is e- learning possible given the context of the delivery situation and other practical considerations?

5. Learner characteristics—do the learners have the necessary skills, attitudes and motivation to conduct e- learning?

6. Instructional management considerations—is e-learning supportable within the wider organisational and cultural context?

7. Cost effectiveness—is e-learning a cost effective medium for delivering instruction?

The authors devote a section on each decision factor and provide further considerations and guidance within. They also provide a detailed description on how these decision factors depend on one another (see Figure 4-4), which can help to understand how novel media will affect an existing training system. For example, the dependency between media attributes and learner characteristic involves an analysis of how the learners' skillset, motivation and other behaviours may affect their use of a specific selected technological solution.

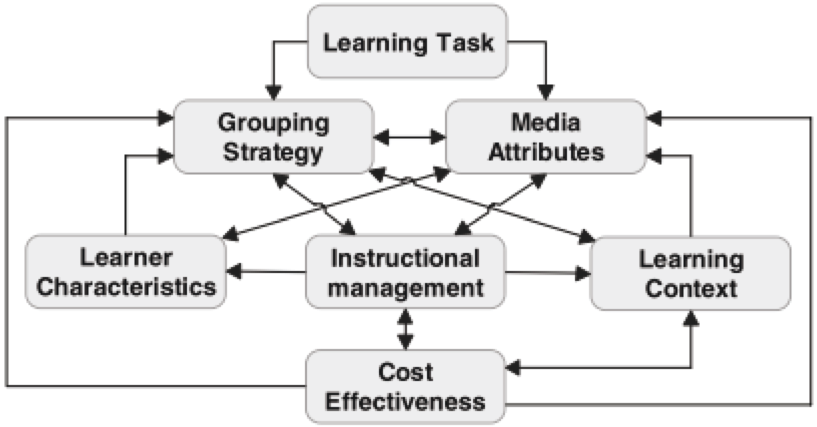

Figure 4-4: Interdependence of Key Decision Factors, (From Huddlestone & Pike, 2008, p. 244)

Suitability of e-learning in each of these areas should be established prior to selecting e-learning as a candidate instructional media for a specific learning task.

In general, Huddleston and Pike's method describes a conceptual framework that can be used to analyze media selection, with a focus of the suitability of e-learning to a particular learning task. The broader framework affords the practitioner insight into connections that exist between other factors, creating complexity when deciding on the appropriate media.

4.5.3 Level of Specificity

This framework has a 'medium' level of specificity. The information provided for each criterion is rich, but most are specific to the e-learning context. Generalizability of this framework would be difficult across other types of learning environments. In addition, no assessment tools or aids were provided.

4.5.4 Evidence for Validity

No evidence found in the literature reviewed and therefore validity was rated as 'none'.

4.6 Koumi's (2006) Media Selection and Deployment Guidelines

4.6.1 Description

Koumi (2006) has come close to developing an actual 'model' of media selection. His model provides criteria for the optimal selection of media focusing mostly on the learning task. Koumi argues against previous studies due to significant methodological flaws. He contends that different media cause significant differences in learning effects. He suggests that the experiments have tried to compare "like with like" by paralleling performance outcomes of students who experience the same content via differing media. According to Koumi, this is an unfair comparison as each medium has its own strengths and weaknesses. Select different media to address different learning tasks and functions for the best outcome. Low quality media used in the experiments may confound results as well. To be a fair comparison, the quality of each medium should be equivalent, but is rarely controlled. Koumi suggests that researchers should stop trying to compare media, but rather rely on the proposed framework and then try to develop and refine the proposed criteria and design to obtain the best effect. Research that includes obtaining student feedback, experts' opinions and student performance metrics on transfer tasks are all ways to iteratively refine and validate a framework.

4.6.2 Information and Analysis Required

The framework proposed by Koumi contains two major factors: a categorization of *comparative merits* of different media, and a more detailed inventory of media-distinctive techniques and related teaching functions (J. Koumi, 2006a, p. 62). The framework includes eight types of media: Radio, TV, Audio, Video, Audio-vision, Print, Computer package and Computer-mediated collaboration. Human mediation, argued to be a crucial aspect, is also included but only as a background factor. When analyzing the media, seven characteristics are considered (from Koumi, 2006a, p. 62):

1. Symbol system – e.g., text, video, sound
2. Access – student's ability to retrieve and use the medium
3. Controllability – students influence over how they use the medium
4. Student reactivity – opportunities for student activity
5. Interactivity – feedback provided
6. Adaptivity – adapt based on individual needs
7. Networking – enables cooperation between students and teachers

Koumi's *comparative merits* are a comparison of one type of media versus another, for example, "Personalizing the teacher is a merit of audio-visual media compared to print" (J. Koumi, 2006a, p. 64). This framework provides the user with tables of comparative merits that suggest "desirable features" of one versus another medium. The model includes tables comparing many-to-many, for example, one group of media compared to another group. Figure 4-5 provides examples of comparative merits. The media is then analyzed for each merit across each of the media seven characteristics listed above (J. Koumi, 2006b).

1 Audio-visual (broadcast or recorded) *over* **Print**
1.1 unique ways to help learning, e.g. drama, animation, demonstration
1.2 provision of realistic experiences, e.g. sounds, places, events
1.3 the medium's realism has a strong impact on attitudes, appreciations, motivations
1.4 personalization of teachers
1.5 breaks the tedium of print
(See Table 4.2 for a finer subdivision of 1.1 to 1.5)
1.6 literacy is not essential

2 Print over **Audio-visual (broadcast or recorded)**
2.1 random access at the student's own pace helps the study of
- data in quantity, e.g. glossary, study guide
- fine detail, e.g. equations, photos

2.2 student can browse and select more easily
2.3 print can carry more information
2.4 print is adequate to cover most of syllabus
2.5 easier teacher access/control
2.6 production skills are adequately resourced
(See Table 4.3 for more detail on 2.1 to 2.6)
2.7 reception is not affected by power outages
2.8 family does not dispute access

Figure 4-5: Examples of Koumi's 'Comparative Merits'
(From J. Koumi, 2006a, p. 65)

Koumi provides specific teaching related attributes for each media type, in finer detail, to aid in media selection. Essentially Koumi analyzed each medium individually and identified the teaching functions where they each excel when compared to others.[10] This provides an inventory for media selection to enable a match to user and training requirements. Further, this framework links the learning outcomes afforded by media and its combinations. The matrix (Figure 4-6) comprises six rows of cognitive processes, with four columns of knowledge dimensions (facts, concepts, procedures and metacognitions), based on Bloom's taxonomy. Each of the 24 cells identifies a particular kind of learning outcome, e.g., "apply procedures".

		Knowledge dimension			
		A. Facts	B. Concepts	C. Procedures	D. Metacognitions
Cognitive Process Dimension	1. Remember				
	2. Understand				
	3. Apply				
	4. Analyse				
	5. Evaluate				
	6. Create				

Figure 4-6: Revision of Bloom's Taxonomy of Learning Objectives
(J Koumi, 2015, p. 2)

Relying on the data and tools provided, educators and ISDs who intend to develop and implement media can evaluate which of their intended outcomes (e.g., matrix position 1. A. Remember - Facts) can be advanced by which type of media.

Koumi provides evidence-based guidance on six specific media; print, TV, radio, video, audio and audio-vision, and how they compare to one another as a function of techniques and

[10] Note that a similar framework can be found in (Clark, 1989)

teaching functions. Koumi provides a three-stage approach to selecting appropriate media (from Koumi, 2006a):

1. List comparative merits and teaching functions:

    a. Although Koumi does not explicitly state this, prior to this phase a TNA would identify the instructional objectives. Comparative merit tables and the inventory of the media-distinctive teaching functions would then be referenced in relation to the training needs identified.

2. Devise a procedure for an analysis based deployment:

    a. Koumi suggests that the user create their own procedure for media selection based on the analysis and outcome of the previous phase. In essence, this phase has the user matching each task with the medium that best fits the topic based on the evidence provided by the tables in the framework.

3. Exploit each medium's potential:

    a. Koumi believes that the appropriate use of media and proper design will result in improved learning outcomes. Therefore, he stresses that during the design phase, the development team should ensure that each medium chosen be exploited to its full potential.

4.6.3 Level of Specificity: High

The level of specificity of this framework is rated as 'high'. Comparatively to others reviewed in this work, Koumi's framework is more prescriptive. He compares the attributes of each media type and provides a basis for developers to select and deploy the courseware. Evidence is the basis for the analysis and exploitation of suitable media. However, it is not modular in nature and if there is media one would like to use that is outside of the 6 included in this framework, the designer may not feel supported in their decision making process. In addition, when comparing this work to others reviewed, Koumi does not seem to address non-pedagogical issues in any detail: such as cost, cultural attributes and organizational issues. Therefore, this model may nicely complement other media selection methods.

4.6.4 Evidence of Validity

Evidence for validity is rated as 'low'. Although no explicit evidence was found for validity in the literature reviewed, the composition of Koumi's framework relied iteratively on theorists and practitioner's feedback and input, which could be evidence for some level of internal validity.

Although the information the author provides in the tables is instructive and useful, the evidence for validity is lacking. The author himself prefaces his work by stating that his framework is one that should drive future research on media selection and the comparisons between each, and is by no means 'conclusive'. Note that model relied on the UK Open University to vet all content and provide recommendations, and based on experiential learning at the University's Production Centre, where he works. Nevertheless, this model provides designers with guidelines to rely on that could potentially initiate future.

4.7 Media Selection for Training

4.7.1 Description

Upon review of media selection models, Sugrue and Clark (2000) concluded that the most common practice is to select appropriate media based on the task type, the trainee type, and the element of training (i.e., instructional event) being delivered. This is of course in addition to external considerations, such as size and location of audience, or cost of development and delivery. At the conclusion of their review, Sugrue and Clark identified that a missing piece in the models was the link between training elements and media selection to associated cognitive components. The authors recommend that "media be selected based on their ability to deliver the level of external support required to compensate for trainees' inability or unwillingness to engage in the cognitive processes necessary for learning"(Sugrue & Clark, 2000, p. 17). In general, it still involves an analysis of the required instructional methods; the media attributes to support the selected training methods, and ancillary factors (cost, organizational, etc.), which is consistent with other models.

Sugrue and Clark (2000) provide an approach to media selection for training that includes an in-depth analysis of the use of media, media attributes, and instructional methods. They make it clear that there a significant difference between media and methods of instruction and media attributes exist. They believe that each plays a role in media selection, but that only the actual methods of instruction affect the cognitive processes related to learning. Conversely, the choice of media links to cost, access, or time to learn, where the instructional methods do not. Sugrue and Clark (2000) focus primarily on the support of cognitive processes involved in learning and propose that media selection begins first with the selection of instructional methods that support these processes, followed by the analysis of media.

4.7.2 Information and Analysis Required

The general approach of this method has three stages (Sugrue & Clark, 2000, pp. 17, 18):

1. Training Methods Selection: selection of methods to support the cognitive processes necessary for trainees to acquire the task performance that is the target of the training;

2. Media Attributes Selection: selection of a set of media attributes that can support the type, amount, timing, and control of methods selected for the training; and

3. Selection of a Final Combination of Media: selection of the most economical and convenient set of media that possess all of the required attributes.

Training Methods Selection: In this first stage, the authors have categorized the available methods into six categories based on the cognitive factor supported;

- interpret goal,
- encode/retrieve knowledge,
- compile new knowledge,
- monitor performance,
- diagnose source of error, and
- adapt.

Designers need to select the type, amount, timing, and control of methods (i.e., who will control the deployment) for the solution. Figure 4-9 summarizes this phase in nine steps. This method provides detailed information regarding each category and the information required to complete the analysis. The authors also provide a graphic that contains information regarding the media attributes that most closely relate to each of the six methods. The designer can move to the second stage (selection of media attributes) once the instructional methods have been chosen.

	Instructional Method Selection Procedure
	Select:
Step 1	Type of goal elaboration (description and/or demonstration)
Step 2	Type of information (description and/or demonstration)
Step 3	Type of practice (high and/or low contextual authenticity)
Step 4	Type of support for monitoring (data collection or guidance)
Step 5	Type of support for diagnosis (analysis or guidance)
Step 6	Type of adaptation (goal/information/practice; or guidance)
Step 7	Amount of each method (low or high; fixed or variable)
Step 8	Timing of each method (fixed or variable; immediate or delayed)
Step 9	Locus of control for each method (system, trainee, or shared)

Figure 4-7: Phase 1: Instructional Method Selection Steps, from Sugrue and Clark (2000, p. 52)

Media Attributes Selection: The training methods selected in stage 1 will determine what is required from the media to facilitate learning. Media attributes (transmission, storage, recording, processing, and retrieval) are determined for each of the six training methods required. For example, the "storage" attributes refer to the medium's ability to store different types and amounts of information, and the "recording" attributes refer to the medium's ability to record any student input.

Authors suggest that different attribute categories (transmission, storage, etc.) are more relevant to certain instructional method categories (goal elaboration, information, etc.). Provided guidelines summarize which media attributes relate to which training methods (Figure 4-8). Sugrue and Clark provide details for each category of methods and their related media attributes to further guide the designer. Figure 4-9 lists the five steps necessary to complete the media attributes selection stage.

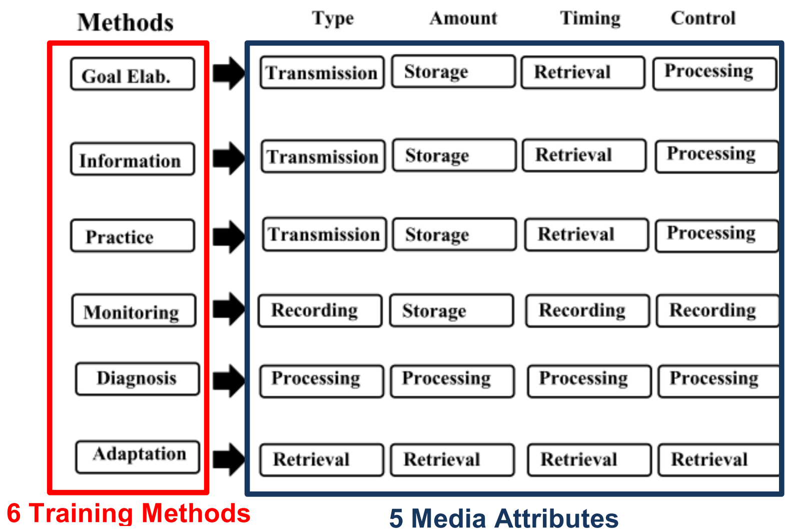

Figure 4-8: Media Attributes related to Instructional Methods, adapted, from Sugrue and Clark (2000, p. 54)

	Media Attribute Selection Procedure
	Select:
Step 1	Transmission requirements for Goal Elaboration, Information and Practice
Step 2	Storage requirements for Information and Practice
Step 3	Recording requirements for Monitoring
Step 4	Processing requirements for Diagnosis
Step 5	Retrieval requirements for Information and Adaptation

Figure 4-9: Media Attribute Selection Steps, from Sugrue and Clark (2000, p. 55)

Selecting a Final Combination of Media: The goal of this phase is for designers to maximize access and efficiency while also ensuring the solution is an economical. Decisions include whether the training can be provided by a human or computer (function allocation), and the type of visuals and practice environment that may be required. Figure 4-10 summarizes the steps and criteria for making final media selections.

	Final Media Selection Procedure
	Select:
Step 1	Computer or human **if** processing attributes required for diagnosis or adaptation
Step 2	Visual medium **if** transmission of visual demonstrations required
Step 3	Real job environment, computer simulation of job environment, or other medium to simulate job environment **if** high level of contextual authenticity specified for practice
Step 4	Least expensive or most accessible media that possess the remaining transmission, storage, recording and retrieval attributes required to deliver the methods specified in the training design

Figure 4-10: Final Media Selection Steps, from Sugrue and Clark (2000, p. 55)

4.7.3 Level of Specificity: Medium

This framework has a 'medium' level of specificity as it pertains to media selection. It is easily generalizable to all types of training environments and according to the authors, able to be extended to performance support systems, and possibly other contexts. There is detailed information provided for each stage and steps, and case studies used to visualize how the process can be used practically are also provided. A number of tools exist in the way of summarized steps to follow, making the process easier to follow and slightly prescriptive. It can be argued that the process lacks information regarding when to select which type of media, but instead leaves it to the designer to investigate and analyze the media attributes best associated with each type of media (e.g., as done by Koumi, 2002). In addition, knowledge regarding cognitive processing would be required and given the numerous steps, sub-steps and categories of information, (methods, attributes, cognition etc.) designers could find this process cumbersome and complex. The information and knowledge required goes beyond the scope of one area of expertise and would require a team of SMEs to implement.

4.7.4 Evidence of Validity

The level of evidence for validity is rated as 'none' as there was no evidence found for validity. As with other reviewed frameworks, this process lacks scientific rigor, not denied by the authors. Ideally, it would include prescriptive rules and algorithms based on scientific evidence.

4.8 Validation of Media Selection Methods

According to Bates (2015b) and conversations with SMEs there seems to be no empirically validated theory or process that supports media selection. Models described in this report can help guide users by providing questions and criteria to consider while make decisions about media and instruction; however, they have yet to be empirically validated. The actual decision making process may be informed by the criteria and associated data, but the analyses are not prescriptive in nature and in the end, the decision is left to the designer. Evidence supporting the lack of an empirically-based model for systematic selection of instructional media is persistent throughout relevant literature and includes the following quote from leaders in field:

> *"I always advise my graduate students never to write 'There is no previous research on this topic', because there always is[…] Similarly, I am cautious about saying that there are hardly any usable, practical, empirically-based models for media selection – but I think it's true." (Bates, 2015a)*
>
> *"There does not exist a sufficiently practicable theory for selecting media appropriate to given topics, learning tasks and target populations . . . the most common practice is not to use a model at all. In which case, it is no wonder that allocation of media has been controlled more by practical economic and human/political factors than by pedagogic considerations".* (Jack Koumi, 1994, p. 56)
>
> *"Media selection is NOT (and may never be) a precise science...charts are simply intended to organize that activity in a more systematic and thorough manner." (Anderson, 1983)*[11]
>
> *"One would like to think that organizations applying systematic or objective approaches would make better decisions than organizations making decisions based largely on intuition or experience. Unfortunately, there is little research evidence to support the superiority of systematic selection. The only two published studies we find that have attempted to examine the relative merits of media selection models and intuitive approaches produced conflicting results." (Sugrue & Clark, 2000, p. 5)*

The literature review conducted on the various media selection methods did not reveal significant evidence for validity, however, there are specific reasons for this finding. Throughout the reviewed literature there were numerous comments regarding the lack of scientific rigor and evidence to support the information that relayed in media selection methods. Sugrue and Clark (2000) state "selection models have given an illusion of rationality and scientific precision to what have been, at best, decisions driven by practical and economic considerations and, at worst, decisions based on invalid assumptions about learning, learners, and the effects of media on them" (2000, p. 1). Apart from quantifiable contextual factors such as cost and cultural considerations, media selection relies on subjective judgement of the designer or SMEs.

A large gap identified in the literature review is the need for systematic validation for the effectiveness of media selection methods on learner performance and transfer. Cost and time may be the driving factors for the lack of validation of methods. In addition, the subjectivity afforded within each method would make it almost impossible to control across different participants. Regardless, internal and external validation is lacking.

[11] taken from (Sugrue & Clark, 2000)

Internal validation refers to the model's reliability between users. That is, do users rely on the methods consistently between each other and between different solutions? One way of ensuring this to rely on a user-centered design process as the method develops. This will ensure that all steps are easily understood, evidence for each step is provided and clear, and that there are no steps missing (Lim, 2006). This type of evidence was not provided publicly for any of the methods reviewed in this report.

External validation focuses on the effectiveness of the models' outcome (the actual impact of the solution) on the learner and other stakeholders. That is, did the media selection model ensure that the solution met all requirements? External validation is much more complicated as it would be almost impossible to parse out the effects of the overall ISD process (e.g., ADDIE) from the effects due to the media selection method, among other uncontrolled variables such as the expertise of the designer.

4.9 Summary

According to researchers, there is conflicting evidence supporting the hypothesis that instructional media improves performance, attitude or retention, known as the "Clark Media debate". Clark [According to Bates (2015b)] argued that there no significant difference can be attributed to differences between the use of different media in scientific literature (2015b, p. 206). There are counter arguments that the methodologies used in previous studies were flawed, as discussed in Section 4.6.1. Taking the most extreme position on media and training effectiveness, one might be tempted to suggest that if media has no positive or negative effect on instructional outcome then perhaps '***how***' media are selected may not matter either.

The media selection models reviewed have numerous overlapping processes or steps, and criterion to consider. While some are more prescriptive in nature and provide frameworks for selecting specific media, others are vague, but afford the user flexibility to interpret the process as they wish and afford the users with the ability to rely on their expertise to make the final decision based on the data and analysis required by the method. As the methods were reviewed, it became apparent that readers might find a comparison of the criteria included across all methods useful. Therefore, Table 4-2 provides the reader with a comprehensive list of criterion to consider, and perhaps may afford them with an overview to select an appropriate method(s) that will support their development decisions. In addition, this table provides an overview of the level of specificity and evidence for validity selected for each method for comparison purposes.

Table 4-2: Comparison of Media Selection Methods by Criterion

	ACTIONS	SECTIONS	CASCOIME	7 Factors	Koumi	Sugrue & Clark
Access	√		√		√	√
Cost	√	√	√	√		√
Teaching	√					

	ACTIONS	SECTIONS	CASCOIME	7 Factors	Koumi	Sugrue & Clark
Learning	√	√		√		√
Interactivity/Engagement	√	√	√		√	
Usability/Ease of use	√	√	√			
Organization	√	√		√		
Novelty	√					
Speed	√					√
Students		√		√		
Networking		√			√	
Security		√				
Socio-political			√			
Cultural			√	√		
Flexible/ Collaborative /Adaptable			√	√	√	
Motivational			√			√
Task				√		
List of Media Types/Symbol System					√	
Cognitive processes					√	√
Specificity	Medium	High	Medium	Medium	High	Medium
Validity	Medium	Medium	None	None	Low	None

It is unknown whether systematic means, such as the methods reviewed in this report, are relied upon in practice, as it is assumed that the design of training solutions and the methods used are rarely published in a public forum. In addition, technology is continuously changing and models that are too prescriptive in terms of which media to select will not stand the test of time if they unless they are built in a modular way. Based on the current review, there does not seem to be a theory, model, method or framework for selecting media appropriate across all topics, tasks, types of learners, and other contextual factors. Based on discussions with SMEs the selection of media is most likely still centred on economic, human, and organizational factors than by following systematic methods. As stated by Bates (2015a, p. 266) “finding a practical, manageable model founded on research and experience has proven to be challenging.

In conclusion, it is argued that the existing media selection methods reviewed seem insufficient when used on their own for making decisions about which media to use for a particular result. A combination of methods may be the best solution and the methods selected would depend on the context and complexity of the environment to be designed. Designers may be relying on more generic methods and customizing them to support their needs, by eliminating steps and adding their own throughout the process. In addition, research reviewed suggests that other aspects such as the learner goals and objectives, subject matter, age, skill level, fidelity of technology, and cognitive functions to be supported may all have a significant influence on the outcome of the media selected and implemented.

5 SIMULATION AND LEVEL OF FIDELITY

5.1 Level of Fidelity

Parallel to selecting the appropriate medium within computer-based solutions, is selecting the appropriate level of fidelity within the domain of modeling and simulation for Simulation Based Training (SBT). A formal definition of fidelity includes:

> *"The degree to which a model or simulation reproduces the state and behavior of a real world object or the perception of a real world object, feature, condition, or chosen standard in a measurable or perceivable manner; a measure of the realism of a model or simulation; faithfulness. Fidelity should generally be described with respect to the measures, standards or perceptions used in assessing or stating it." U.S. Department of Defence, Modeling and Simulation Coordination Office (Modeling and Simulation Coordination Office (MSCO), U.S. Department of Defense, 2000; 2011).*

The definition above focuses primarily on the physical aspects of the simulator. Taylor (1999, p. 333) expresses the opinion that while physical similarity to the real world is useful for gaining user acceptance, it is not sufficient (and probably not necessary) to ensure effective training. Instead, educational researchers propose that the standard for assessment of a learning environment, such as a simulator, should also focus on its psychological or functional[12] fidelity (Ross, Phillips, & Cohen, 2009; Timson, 2013). In general, the literature proposes that three categories of fidelity exist: Physical, Functional and Psychological.

1. **Physical fidelity** is the extent to which the system looks, sounds and feels like the real environment. In essence, it is the degree of similarity between the appearance and cues provided by the simulator to the appearance and cues present in the real environment. The cues include "those that represent the sensory perceptual experience and are experienced via the human's multiple sensory modalities" (Padron et al., 2016, p. 5). These cues include motion, motion cues, visual displays and flight models for example.

2. **Functional fidelity** is the ability to support the appropriate stimulus response set (Peter Muller et al., 2006, p. 3); or the degree of accuracy in system operation (Thomas, 2003, p. 1). Functional fidelity corresponds to the degree to which the tasks in the real world are mimicked in the simulated one.

3. **Psychological/cognitive fidelity** is the "degree to which simulated tasks reproduce behaviours that are required for the actual, real-world target application" (Stone, 2011, p. 279), e.g., does the student perceive the simulator as the "real environment" and are the same cognitive and emotional processes experienced?

[12] Some authors use the term "functional fidelity" to refer to the abstract behaviour of the operating environment and equipment, which is more similar to the term "engineering fidelity" than the definition used here.

As argued in the selection of appropriate medium for CBTs, it is also important that decisions regarding selecting the appropriate level of fidelity be driven by evidence. Conventional wisdom suggests that higher fidelity levels result in better the transfer of training. The ‘identical elements theory’, originally proposed by Thorndike (1906), states that the more identical a simulator is to reality, the better the learning and transfer of training. This principle originally drove designers to design high fidelity training solutions, usually at great cost.

Thorndike’s hypothesis is still widely accepted; however, researchers have questioned the validity or at least the necessity of this principle for effective learning (Liu, Macchiarella, & Vincenzi, 2009) and some have found evidence that there may be an optimal level of fidelity and anything beyond that level provides no additional benefit (Noble, 2002). Most designers recognize that many features of an operational environment cannot be feasibly replicated and their representation is an approximation only. Indeed, many educational researchers recognize that it may be disadvantageous to reproduce the operational environment by default as its complexity is often bewildering to novices and perhaps not even properly understood by experts in the domain.

It should be noted that cost-effective does not necessarily imply low cost (i.e. low quality), only that the cost of obtaining effective training is less than alternative methods such as using operational equipment (Pongracic et al., 1997). Indeed, there is considerable evidence supporting the position that low-fidelity simulators are as effective as high-fidelity simulators for training effectiveness (Norman, Dore, & Grierson, 2012; Salas, Bowers, & Rhodenizer, 2009) and in some instances, low-fidelity simulations outperform high-fidelity simulations (Smallman & Cook, 2010; Smallman & John, 2005).

Taylor (1999, p. 333), amongst others from the learning research domain, have expressed the opinion that while physical similarity is useful for gaining user acceptance, it is not sufficient (and probably not necessary) to assure effective training. In fact, the focus on increasing fidelity in an attempt to improve fitness-for-purpose is likely misguided as perception is selective and it is difficult to assess exactly what cues operators are actually being relied on for learning compared to what they believe they are using (Stoffregen, Bardy, Smart, & Pagulayan, 2003). Nevertheless, the training environment should adequately represent the operational environment to a degree to promote effective training (Grossman & Salas, 2011).

Simulator capabilities should be matched to the intended purpose (fit-for-purpose) and that what may be appropriate in one context may be inadequate in another, as is the case for media selection. There seems to be little benefit to creating a training simulator that has all of the features of the aircraft but that do not figure into any training objectives. The inclusion of unused and often complex features increases the simulator cost exponentially, but with very little return on investment and may decrease training effectiveness particular for the novice student (Duncan, 2006). US rotary-winged simulation-based research suggests that the level of fidelity be aligned with the training objectives. For example, it is not effective to train system operation using a full-flight simulator. It can be done, but there is the risk of cognitive overload for environmental representation outside the scope of the training focus, and it is not cost-effective (Stewart, Johnson, Howse, & Sams, 2008).

Contrary to general beliefs and opinion, the training research community commonly accepts that physical fidelity, the usual interpretation of the term fidelity, is not well correlated with effective learning and that overall instructional approach is more important (Salas et al., 2009; Salas, Milham, & Bowers, 2003; Salas & Burke, 2011). The issue then remains to be determined regarding ***what level of "fidelity" is required*** that enables cost-effective learning and training transfer to the operational environment and what factors play a role, e.g., skill level, domain, type of environment, trainer etc.

Traditionally, and currently, the practice is to rely on SME's subjectively driven design decisions. However, some SMEs may rely on literature reviews, empirical studies, and modeling to aid in selecting the appropriate level of fidelity. Efforts to make the decisions more objective and efficient utilize task analyses so that all subtasks are identified along with their related physical, functional and psychological cues. These cues can then be linked to supporting technology options (e.g., Champney, Carroll, Milham & Hale, 2008; R. K. Champney, Stanney, & Carroll, n.d.; Milham et al., 2009; P. Muller et al., 2006).

The biggest challenge when selecting the level of fidelity is to determine the fidelity requirements that result in the most effective training environment. A critical issue is that the level of fidelity required for cost-effective simulation has not been well established (Pongracic et al., 1997). Two methods for selecting the appropriate level of fidelity reviewed in this report attempt to objectify the process. The two described were selected based on recency of publication and the process prescribed.

5.2 The Fidelity Matrix

5.2.1 Description

Ensuring that training systems have human factors assessments throughout the design and development phases (formative) as well as Transfer of Training (ToT) evaluation (summative) once integration occurs affords early identification of issues early on and throughout the development lifecycle (P. Muller et al., 2006, 2009). However, this approach may not be followed by designers and developers (and therefore not well documented) as time and budgets constrain this level of assessment (P. Muller et al., 2009). The cost associated with not completing formative human factors assessments can be exponential as the cost associated with re-development further down the development lifecycle is far greater than that associated with redesign changes prior to any development. Muller et al (P. Muller et al., 2006) describe a large-scale research effort, titled "The Virtual Environments and Technologies" (VIRTE), a program that emphasizes the role of component analysis throughout the design and development process, with an emphasis on fidelity analysis.

5.2.2 Information and Analysis Required

Muller et al. suggest a three stage component-wide analysis during design and selection of the level of fidelity and include the following steps:

1. Requirements analysis: Identify the training requirements and objectives (i.e. task analysis, job/training analysis). For example, in relation to VIRTE a sensory task analysis was conducted to determine the multi-modal requirements, i.e., the tasks were decomposed into their sensory elements (visual, haptic, auditory, etc.) and critical training design needs were identified to support each task.

2. Component selection: Determine how to represent the cues in the VE by identifying the component technologies that will support the requirements (i.e. operationally realistic, visual, auditory, haptic, or metaphoric). As components and the associated level of fidelity are selected, “Intermediate Feasibility Experiments (IFEs) and formative assessments must be undertaken at key points within the development cycle to evaluate progress-to date and, if necessary, to propose alternate development solutions” (Muller et al., 2003, p. 3)

3. Transfer of Training: ToT evaluations are conducted to validate that the design has met the requirements, once the solution has been implemented. This usually involves the comparison of two groups, one that is exposed to the current training and one that is exposed to the new training. Once the training is completed, the groups’ performance in in a real-world scenario are compared.

Step 2, component selection, resembles “media selection” methods and was the focus of the paper by Muller et al (2006). The authors first identified the training requirements and objectives, followed by the identification of component technologies used to build the solution. The same challenge identified in Section 4, mapping the specific media to the training requirements, is also identified when selecting components and associated fidelity. As Muller et al stated “the challenge is to map the desired training to the type of training technology and then identify the types of technologies that need to be integrated to support this system” (Muller et al., 2006, p. 2). The authors also state that the specifications for each piece of the solution should be based on evidence from human performance tests and evaluations, and therefore easily mapped to a requirement. Unfortunately, this is rarely the practice as it is cost and time prohibitive.

For VIRTE the components were evaluated to gain an understanding of their influence on students’ performance. Authors identified, based on literature, the types of systems that were likely to be effective. They used the amalgamated data, found in Table 5-1, to identify the level of fidelity that would best suit their training solution as well as the issues that they may face. In this design the authors were most concerned with how to blend multiple modalities to create a realistic experience. The modalities of concern included visual displays, navigation, locomotion, as well as haptic and auditory interactions. At this point, a sensory task analysis (STA) was conducted to identify multi-modal requirements. An STA is a type of task analysis “used to decompose an operational environment to understand how a learner gathers, processes and reacts to cues in the environment” (R. K. Champney et al., 2014, p. 2356)[13]. Once these were

[13] See Champney et al (2008) for a usable STA methodology and tool called “SPOT” (Sensory, Perceptual, Objective Task). The SPOT method is intended for use by non-human factors practitioners.

identified, the operational cues required to meet the requirements, by modality, were determined.

Table 5-1: Training Options to Optimize Training Effectiveness (Based on Theory) (P. Muller et al., 2009)

Type of Training	Target of Training	Issues
School House Functional Fidelity: Low Physical Fidelity: Low Psychological Fidelity: Low	Declarative knowledge, facts	Difficult to practice skills and consolidate knowledge
Low Fidelity (partially immersive) Functional Fidelity: High Physical Fidelity: Medium Psychological Fidelity: Low	Consolidate declarative knowledge and acquire procedural knowledge	Difficult to acquire higher-order skills and strategic knowledge
High Fidelity (fully immersive) Functional Fidelity: High Physical Fidelity: High Psychological Fidelity: Medium	Higher-order skills and strategic knowledge (e.g., SA, team coordination)	Can overwhelm and distract early declarative and procedural learning; Cost; Limited availability; may require support staff to run
Live Functional Fidelity: High Physical Fidelity: High Psychological Fidelity: High	Higher-order skills and strategic knowledge (e.g., SA, team coordination)	Can overwhelm and distract early declarative and procedural learning; Cost; Limited availability; may require expert trainers to run

This was an extensive effort and included numerous studies each comparing systems containing mixed modalities to determine the optimal solution. For example, the designers needed to understand the optimal level of fidelity associated with locomotion and visual displays. To do this they ran a set of studies comparing task performance across different visual (normal, restricted field of view, head-mounted display) and locomotion (walking, walking-in-place, joystick walking) interface conditions with the intention of ranking the best solutions. Other studies were conducted on kinesthetic feedback, haptics, and aural human factors issues. These studies resulted in identifying two types of systems that could be developed that met the original requirements; one they considered a low fidelity solution and a second high fidelity training solution.

There is very little guidance regrading how to approach the challenge of selecting the right level of fidelity to date (Muller et al., 2006, p. 4), however this paper provides an example of an approach regarding how the level of fidelity by components can be identified.

5.2.3 Level of Specificity

The level of specificity is rated as ‘medium’ as the matrix provided is useful to help determine the specific level of fidelity as it relates to training type and provides evidence-based issues related to each level. In addition, separating the analysis and research by component type is fairly detailed and specific to the case study provided. However, it could provide a framework that other practitioners may follow to conduct research and determine the fidelity of each component in their solutions.

5.2.4 Evidence of Validity

The evidence for validity is 'medium' as the authors relied on a case study to validate (internally) their approach by way of empirical research. However, no evidence of external validation has been located and very little follow on research has cited this work to date. Authors believe that their systematic methodology for identifying the technology components necessary for developing a blended fidelity training solution fills a gap in the training community. In addition, the notion that there may not be only one 'best solution' and that numerous options can be identified is interesting as there may be other factors or criterion such as cost, culture and organization that play a significant role in the final selection.

5.3 Human Experience Approach to Optimizing Simulator Fidelity

5.3.1 Description

To select the appropriate level of fidelity is a challenge in that the process is complex and involves SMEs from training and human factors and a subjective perspective on the final choice is required. Champney et al. (2014) attempted to create a more objective process for identifying the value of the effective level of fidelity. They labeled this process "the human experience-based approach to fidelity optimization". The essence of this process is a task analysis supplemented by a tool used to identify the human related experiential cues per task.

As discussed in the previous section, Muller et al (2006) decomposed the training tasks into their sensory cues in order to match them to the right modality and conducted numerous studies in order to gain an understanding of the impact of various levels of fidelity on each modality. Champney et al. (2014) argue that although this is a good starting point, sensory cues, which are related to physical fidelity, are only one piece of the fidelity selection process and so they chose to incorporate requirements related to functional and psychological fidelity as well. To fill the gap the authors expanded on a usable STA methodology and tool called "SPOT" (Sensory, Perceptual, Objective Task analysis) intended for use by non-human factors practitioners and include functional and psychological fidelity (Champney, Carroll, Milham, & Hale, 2008).

The SPOT process includes a decomposition of human capabilities related to physical fidelity, of which there are a finite number. The challenge then was to do something similar with functional fidelities that contain an infinite number of items as it depends strongly on the training domain and mission at hand. In order to define the functional fidelity taxonomy, the authors suggest that the taxonomy be constrained by some boundary, for example by domain, for example, aviation, navy, or army related functions. The same is true for psychological fidelity, as the number of cues affecting someone can be infinite, and include not only the experience perceived but also cognitive experiences as well as emotional ones. To mitigate this challenge, authors suggest that psychological fidelity can be defined in a finite way if it is thought of in terms of "the cognitive process influencing the experience, and the emotional cues present during the experience" (R. Champney et al., 2008, p. 2357). To select the most optimal level of fidelity authors suggest that each training element relate directly and objectively to an element of fidelity. The data that feeds into this would come from the TNA, expressed in terms of a function (i.e. skill decay) and the associated skills and knowledge required.

5.3.2 Information and Analysis Required

To provide practitioners with a usable method, authors collaborated with SMEs to create a Training Needs Index (TNI), which includes three factors:

1. Skill decay: the likelihood of decay due to task difficulty, task execution frequency, and prior experience performing the task;

2. Task Practice: the level of practice currently provided during operations for a task, including amount, frequency and quality of practice; and

3. Simulation Need: whether such training could benefit from simulation-based training based on the task risk, criticality (critical task identified) and resources required.

These three factors form the basis for the TNI metric, which determines the relative importance of a task's simulation-based training need. Table 5-2 provides a summary of the factors identified in the TNI.

Table 5-2: TNI Factors Identified; from Champney et al. (2014, p. 2357)

Skill Decay	Task Practice	Simulation Need
• Task difficulty • Degree of prior learning • Frequency of task performance	• Amount of task practice • Frequency of task practice • Quality of task practice	• Task Risk • Task Resources • Task Criticality

Authors provided a case study in which they attempted to validate their method using the proposed TNI measure in three steps:

1. Create fidelity cue reference tables: these tables of decomposed tasks will afford the practitioner to map each to the associated fidelity requirements. Table 5-3 provides an example of the physical, functional and psychological fidelity cue tables. Authors believe that creating these tables helps to simplify the task analysis, which affords non-human factors practitioners with a usable method, and provides an objective way of documenting cues related to each task. The authors also believe that this method aids in the development of traceable system requirements. Again, in reference to the functional fidelity, the scope is defined prior to decomposing the tasks, which should be based on the chosen mission or

scenario selected for training (in the tables provided, the authors used the example of a combat medicine scenario).

Table 5-3: Examples of Physical, Functional and Psychological Fidelity Reference cue Tables, from Champney (R. K. Champney et al., 2014, pp. 2357–2358)

Generic Human Cue	Minimum Fidelity Requirement
• Visual – Depth perception <3 meters	• Binocular Vision
• Visual – Depth perception 3+ meters	• Pictorial Cues
• Auditory - Detect/Register Sound (Detect Sound Occurrence)	• Mono Sound Capability; Frequency Content of Sound (20Hz – 20k Hz)

Human Patient Functions	Minimum Fidelity Requirement
CNS Functions – Alertness	• Eyes – alertness indicators: Pupil Dilation to Light, Eye Blinking, Eye Movement, Tears.
	• Hearing – alertness indicators: Response to verbal cues, Ear fluid leak (clear & blood)
	• Nose & Mouth – alertness indicators: Mouth operation, Speech capability
	• Motor – alertness indicators: Gross limb movements
	• Pain – alertness indicators: sensitivity to pain

Combat Medicine Cues	Minimum Fidelity Requirement
• Visceral – Disgust	• Blood presentation • Pain Sounds presentation
• Event – Fear	• Prospect of dying comrade
• Symbolic – Shame	• Prospect of death due to mistake
• Stress – Enemy Hostility	• Incoming gun fire

2. Cue task analysis: To optimize fidelity, the practitioner conducts an experiential cue task analysis using the cue reference tables. The operational environment is decomposed into its functions and tasks, which are then assessed for training needs using the TNI. Each task or subtask is analyzed for the physical, functional and psychological cues required. Using the combat medicine scenario, the authors provide an example of the completed cue task

analysis in Table 5-4. The subtask is “forming an impression of the casualty’s condition”, and the identified domain cues include “breathing and bleeding”. For each of the domain cues, the physical, functional and psychological fidelity are assessed and identified.

Table 5-4: Example of an Experiential Cue Task Analysis in the Combat Medicine Domain (from R. K. Champney et al., 2014, p. 2358)

Sub-Task	Domain Cues	Fidelity Cues
Forms an impression of the casualty's condition	Breathing rates (rise and fall of chest)	• *Visual*: Visual Detection of Cue in Field of View • *Functional*: Respiratory Functions, breathing quality • *Functional*: Respiratory Functions, airway anatomy • *Psychological*: Event - Fear • *Psychological*: Stress - Enemy Hostility
	Bleeding (open bleeding or bleeding through bandages)	• *Visual*: Visual Detection of Cue in Field of View • *Functional*: Musculoskeletal Soft Tissue Damage, compressible hemorrhage • *Functional*: Musculoskeletal Soft Tissue Damage, non-compressible hemorrhage • *Psychological*: Event - Fear • *Psychological*: Stress - Enemy Hostility *Psychological*: Visceral - Disgust

3. Fidelity Requirements Optimization: After fidelity cues have been identified in step 2, the associated requirements are determined for each task using the reference tables from output. The optimization occurs with an assessment of the impact using a scale found in Table 5-5. The TNI results and the results of the optimization assessment affords the practitioner with the ability to evaluate the cost and benefit of each fidelity cue, which will guide the final decision making process regarding the level of fidelity.

Table 5-5: Fidelity Cue Impact Rating Scale Used (from Champney et al. 2014, p. 2359)

• Cue Not Necessary- The cue is not necessary for effective execution of the task. • Cue Enhances- The cue enhances the effective execution of the task. • Cue Supports- The cue supports the effective execution of the task. • Cue Required- The cue is required for the effective execution of the task.

5.3.3 Level of Specificity

The level of specificity is rated as 'high' as the method considers all types and levels of fidelity and provides very detailed analysis pathway for practitioners to follow. In addition, the authors provide a reference to an external analysis, SPOT, which can be relied on to identify the physical fidelity requirements.

5.3.4 Evidence for Validity

The evidence for validity is 'medium' as the authors provided evidence for internal validation. The development of this method relied on SMEs (developed cue tables) and has been tested by the authors for its feasibility. Authors found that the evaluation of the method proposed was positive and stated that the practitioners found that the approach was more objective, results were traceable and were supported by evidence. Authors are continuing to validate this approach currently.

5.4 Summary

The two methods for selecting the level of fidelity reviewed in this report are consistent with other methods used in this field (Burki-Cohen, Go, & Chung, 2003; J. Estock et al., 2008; Go, T H; Burki-Cohen, J; Soja, 2000), in that they follow a systems design process that relies heavily on empirical evidence to reveal the impact on performance. For example, Estock (Estock, Steizer, Alexander, & Engel, 2009) compared two fast jet (F-16) flight simulators, one defined as high fidelity (actual cockpit controls and displays, 360º Field-of-view (FOV), and high resolution display) and the other defined as lower fidelity (essential cockpit switches displayed on a touch screen, 108º field-of-view, and a lower screen resolution). Objective (air-to-air mission related skills) and subjective (satisfaction, presence) measures were compared between groups. Subjectively the students believed that the higher fidelity simulator produced better results in performance, however the objective measures did not differ between groups. Therefore, beyond the scope of selecting the right level of fidelity for each component, it may be just as important that designers bear in mind extraneous variables such as user satisfaction and subjective perception of effectiveness, as well as level of experience (expert versus novice). This could be invaluable advice when selecting between high and low fidelity solutions as there is still a lack of empirical evidence stating that transfer of training differs between high and low fidelity solutions (Sparko, Bürki-Cohen, & Go, 2007). In fact there is some evidence that lower fidelity simulation can be just as effective with the advantages of lower cost and ease of use (Dahlstrom, Dekker, van Winsen, & Nyce, 2009).

There is extensive research on low versus high fidelity options, however it may be fruitful to conduct a meta-analysis on all research to date by domain (functional fidelity), in order to produce a broader framework. This evidence-based framework could be used to drive future research, as it would identify the major gaps in the domain's current research and evidence.

A key element of designing simulation based training systems is the need to identify what elements of the operational tasks that need to be replicated in the simulation environment. A balance between too much and too little fidelity is required; fidelity that is too high for the task may result in extreme costs and cognitively overloading the users, particularly novice ones. Not enough fidelity or the wrong level for each type (physical, functional, psychological) may result in systems that do not support training effectively. The right balance will result in the best return on investment (Padron et al., 2016). A challenge is that this process is far from straightforward and often involves subjective assessments by SME's or human factors professionals. A more objective process for identifying the value of the right level of fidelity is needed (Padron et al., 2016).

In summary, although the gold standard is to incorporate as much fidelity as possible and hope for adequate transfer of training, this is not always the case. However stronger and more consistent evidence needs to be provided (Stewart et al., 2008) either for or against this practice. Either method reviewed could be followed when selecting the appropriate level of fidelity, as the focus of both methods is on identifying the requirements up front that will support the training objectives. In addition, user buy-in and satisfaction also seem to play a significant role and are not included in the methods reviewed. The research on ToT from simulator to aircraft has demonstrated that "contrary to institutional beliefs, training strategy has been found to be more important than fidelity with regard to training effectiveness" (Stewart et al., 2008, p. v). Therefore, similar to advice donned in CBT media selection methods, "it may be the design of the entire training program, rather than the individual devices, that will have the largest impact" (Burki-Cohen et al., 2003).

6 RESULTS AND CONCLUSIONS

The objective of this work was to review instructional media selection methods used during the instructional design process (IMI levels 1-3), including to a lesser degree, methods to determine the required component fidelity regarding simulation-based training solutions (IMI level 4). A survey of the literature identified approaches to the problem space, and answered questions of interest for each of the identified methods reviewed where information was available.

The review of training media selection methods included US and Canadian defense sector methods ad well as six additional methodologies from the academic sector. The review included an analysis of the level of specificity and evidence for validation for each method. None of the methods reviewed were rated as having a high level of specificity or validity. In fact, the final media selection decision across all methods reviewed does not seem to be based on any media selection method in isolation, but driven by a combination of intuition, SME experience, and the data collected based on the questions considered in the model, framework or method.

Based on the review provided in Section 4, recommendations and insights regarding media selection for IMI levels one through three include:

1. Defense handbooks and manuals, such as that provided by the CF, could be more prescriptive in nature. It may be useful if these manuals provided references to media selection methods that have made an attempt of internal and external validation, and provide additional guidance by way of tools and aids to practitioners. Table 4-2 provides a comparison of criterion considered by each method. This table (once validated by SMEs) could feasibly be relied upon when selecting an appropriate media selection method. Given that each method has its own focus (e.g., e-learning, distant education, cognitive processes) it is our hope that the comparison table provides some direction regarding the selection of a best-fit method, depending on the context and solution environment. In addition, it is likely that a practitioner would rely upon a combination of methods to design a training solution if one method does not provide enough breadth of criterion. Based on the review and assessment, all methods reviewed captured between six and eight criterion, however the SECTIONS model was rated the highest overall - with a high level of specificity and a medium level of evidence for validity. It can then be suggested that Bates' SECTIONS model could provide the most comprehensive and valid method that was included in this current review.

2. The review provides some evidence that models placing too much focus on specific media types and technologies may prove to be too constraining. Models that seem more flexible and modular may be best for future use as technology is constantly evolving.

3. Apart from quantifiable contextual factors such as cost and cultural considerations, media selection methods appear to be based on the subjective judgement of the designer or SMEs. Therefore, models that are somewhat quantitative in nature, versus solely qualitative, provide practitioners with more traceable evidence for which to base their final decision on.

4. A large gap identified in the literature review is the need for more systematic validation for the effectiveness of media selection methods on learner performance and transfer of training evidence. Cost and time may be the driving factors as to the lack of validation of methods to date. In addition, the subjectivity afforded within each method would make it almost impossible to control across different participants. Regardless, internal and external validation is lacking.

    a. Internal validation of media selection methods is lacking for all methods reviewed. It is recommended that, during development, a user-centered design process is relied upon. This will ensure that all steps are easily understood evidence for each step is provided and clear, and that there are no steps missing (Lim, 2006).

    b. External validation of media selection methods is lacking for all methods reviewed. No studies were located that created training solutions comparing the use of one method to a control group. This would enable us to understand if the method used results in effective training solutions compared to other methods. Again, this is a complicated endeavour as the factors related to selecting media may be impossible to control (e.g., expertise of practitioner, biases, other processes followed such as ADDIE).

In conclusion, leaders in the field are cautious to support any one method as they are not deemed usable, practical, and empirically based as of yet. It can be argued that the existing media selection methods reviewed seem insufficient when used on their own for making decisions about which media to select. Elements from a combination of methods may be best suited and would depend on the context and complexity of the environment.

Parallel to selecting the appropriate medium within computer-based solutions, is selecting the appropriate level of fidelity within the domain of modeling and simulation for Simulation Based Training (SBT). Based on the review provided in Section 5, recommendations and insights were collected and include:

1. When selecting the appropriate level of fidelity in an immersive or interactive system, practitioners may not be able to rely on the media selection methods that are used for the design of less immersive systems. This is because the level of detail regarding the components and the physical, functional and psychological factors related to fidelity are excluded from these methods. Therefore, practitioners need to rely on a systems design process and even more heavily on literature reviews and research if they want empirical evidence that the solution (usually a costly one) will have a positive impact on performance.

2. Selecting the appropriate level of fidelity is a challenge in that the process is complex and a multi-disciplinary team of experts will most likely be required. These experts involve SMEs from operational, training and human factors domains that place a subjective perspective on the final choice.

3. The solution for simulation will be domain and context specific, and there does not seem to be one accurate way of selecting the appropriate level of fidelity. The selection will depend and most likely require some empirical work to determine the best level of fidelity, at least for

some functional and psychological components. Of the two methods reviewed, the Human Experience Approach would be recommended if fidelity beyond the physical needs to be determined.

4. A major gap in the domain is to identify the ability of different levels of fidelity to meet various training objectives. This of course would answer the original questions put forth by the TA and would afford the practitioner with specific data and information regarding how to optimize the solution based on various types and levels of fidelity required. Therefore, future research will need to focus on determining the types and levels of fidelity that is required within each domain and each set of training objectives.

The analysis conducted on media selection methodologies for IMI levels 1 through 4 suggest that media selection is subjective in nature and that additional guidance and tools are required to improve objectivity, and therefore, validity.

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APPENDIX A CASCOIME MODEL MEDIA EVALUATION CHART

From:
http://www.patsulamedia.com/usefo/usableword/report20020201_mediaselection_criteria.shtml

CASCOIME Media Evaluation Chart: *Eight Practical Guidelines for Selecting Media in an International Setting*								
			Media 1		Media 2		Media 3	
	Factor	**Value**	**Rating**	**Score**	**Rating**	**Score**	**Rating**	**Score**
1	**Cost -** Is the medium cost effective? Can it reach a wide enough audience? What technology infrastructure is currently available?							
2	**Accessibility –** Is the medium accessible? Does it facilitate distribution? Is it convenient to use? Is it user-friendly?							
3	**Social-Political Suitability –** Is the medium socially and politically suitable? Does its use coincide with social and political agendas of governing bodies?							
4	**Cultural Friendliness –** Is the medium culturally appropriate? Does it coincide with the culture's traditional way of learning?							
5	**Openness/Flexibility –** Is the medium flexible? Does it foster collaboration? Does it foster different ways of teaching?							
6	**Interactivity -** Is the medium interactive? Does it promote learner-learner and learner-instructor interaction? Does it facilitate timely and quality feedback from instructors and tutors?							
7	**Motivational Value -** Is the medium motivating? Does it encourage learners to study harder and longer?							
8	**Effectiveness -** Is the medium effective? Does it help students learn content faster (i.e., more efficiently)?							
			TOTAL SCORE					

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This work provides an overview of the various methods relied upon by those making decisions regarding the selection of media and level of fidelity found within training solutions. The objective of this work was to review current instructional media selection methodologies used during the instructional design process for computer and simulation based training. A survey of the literature identified approaches to the problem, and answers to questions of interest to the Technical Authority (TA) for each of the identified methods reviewed where applicable and available. Two domains were reviewed, first, Instructional System Design (ISD), concerns itself with the methods used to select the appropriate media for non-immersive training solutions, for example computer-based training. Second, human factors, Human Computer Interaction or HSI literature were reviewed, which concerns itself with higher immersive training (i.e. part task trainers, virtual environments (VEs) and high fidelity environments (live, virtual and constructive simulation). The review of the ISD literature, training media selection methods, included U.S. and Canadian defense sector methods and six additional non-defense methods. The review included an analysis of the level of specificity and evidence for validity for each method. None of the methods reviewed were rated as having a high level of both, specificity or validity. Upon review, there seems to be no empirically validated theory or process that supports media selection. Models described in this report can help guide users by providing questions and criteria to consider while making decisions about media and instruction; however, they have yet to be empirically validated. The actual decision making process may be informed by the criteria and associated data, but the analyses are not prescriptive in nature and in the end, the decision is left to the designer. The final media selection decision across all methods reviewed does not seem to be based on any media selection method in isolation, but driven by a combination of intuition, SME experience, and the data collected based on the questions considered in the model, framework or method. Based on the review, the existing media selection methods seem insufficient when used on their own for making decisions about which media to use for a particular result. A combination of methods may be the best solution and the methods selected would depend on the context and complexity of the environment to be designed. In addition, research reviewed suggests that other aspects such as the learner goals and objectives, subject matter, age, skill level, fidelity of technology, and cognitive functions to be supported, may all have a significant influence on the outcome of the media selected and implemented and not included in current methods. When selecting the appropriate level of fidelity in an immersive or interactive system, practitioners may not be able to rely on the media selection methods that are used for the design of less immersive systems. This is because the level of detail regarding the components and the physical, functional and psychological factors related to fidelity are excluded from these methods. Therefore, two methods for selecting the appropriate level of fidelity for immersive environments were reviewed. It is concluded that either method could be followed when selecting the appropriate level of fidelity, as the focus of both is on identifying the requirements up front that will support the training objectives. Leaders in both fields seem to be cautious to support any one method as they are not empirically deemed usable, practical, and evidence-based as of yet. It can be argued that the existing media selection methods reviewed seem insufficient when used in isolation for making decisions about which media to select. Elements from a combination of methods may be best suited.

13. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g., Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

Simulation, training, learning, media