Technology-Based Learning (TBL) in Workforce Development and Education: A Review of the Research Literature

Contract #GS10F0086K

September 2014

Prepared for:
US Department of Labor,
Employment and Training Administration
200 Constitution Ave, NW
Washington, DC 20210

Submitted by:
Abt Associates
6130 Executive Boulevard
Rockville, MD 20852

MEF Associates
99 Canal Center Plaza
Suite 305
Alexandria, VA 22314

This work has been funded, either wholly or in part, with Federal funds from the Department of Labor, Employment & Training Administration under contract number GS10F0086K. The contents of this publication do not necessarily reflect the views or policies of the Department of Labor, nor does mention of trade names, commercial products, or organizations imply endorsement of same by the U.S. Government.

Suggested citation: Gan, Katherine N., Glen Schneider, Zachary Epstein, and Alex Silverman. 2014. *Technology-Based Learning (TBL) in Workforce Development and Education: A Review of the Research Literature*. Prepared for the U.S. Department of Labor. Cambridge, MA: Abt Associates Inc.

Table of Contents

Acknowledgements ii

List of Acronyms and Abbreviations iii

Executive Summary iv

1. Introduction 1
- 1.1 Organization of the Paper 2
- 1.2 Methodology 3

2. Technology-Based Learning: Basic Concepts, Strengths, and Limitations 5
- 2.1 Review of TBL Concepts 5
  - 2.1.1 A Continuum of Technology Use 5
  - 2.1.2 Advanced Forms of TBL 7
- 2.2 Overview of Strengths and Limitations of Using TBL 8
  - 2.2.1 Monitoring and Assessing Learner Engagement Remotely 9
  - 2.2.2 Adapting Learning to Individuals' Needs 9
  - 2.2.3 Promoting Interpersonal Interaction 10
  - 2.2.4 Saving Costs and Resources 11
  - 2.2.5 Strengthening Access and Readiness 12
- 2.3 Summary 12

3. Considerations for Using and Providing TBL 14
- 3.1 Learner Considerations 14
  - 3.1.1 Basic Skills 14
  - 3.1.2 Technological Access and Readiness 16
  - 3.1.3 Psychological Factors 18
  - 3.1.4 Support for Engagement in TBL 19
- 3.2 Provider Considerations 20
  - 3.2.1 Developer Considerations 20
  - 3.2.2 Procurement Considerations 21
  - 3.2.3 Implementer Considerations 22
  - 3.2.4 Employer Considerations 23
- 3.3 Summary 24

4. Current TBL Use in Workforce Services, Training, and Education 26
- 4.1 Workforce System Program and Services 26
  - 4.1.1 ETA Support for TBL 27
  - 4.1.2 The Use of TBL Within Public Workforce Programs 27

4.2 Career and Technical, Adult, and Developmental Education ... 28
4.2.1 Career and Technical Education ... 28
4.2.2 Adult Education ... 29
4.2.3 Developmental Education ... 30
4.2.4 ED's TBL Initiatives and Guidance ... 30
4.2.5 Prevalence and Use of TBL in CTE and Developmental Education ... 32
4.2.6 Prevalence and Use of TBL Within Adult Education ... 37
4.3 Summary ... 38

5. Empirical Evidence on the Use of TBL for Improving Workforce Outcomes ... 39
5.1 The Effectiveness of Technology-only Interventions for Improving Workforce-related Outcomes ... 40
5.1.1 Asynchronous, Technology-only Interventions ... 41
5.1.2 Design Features of Promising Asynchronous, Technology-only Interventions ... 42
5.1.3 Synchronous, Technology-only Interventions ... 44
5.1.4 Design Features of Promising Synchronous, Technology-only Interventions ... 46
5.2 The Effectiveness of Blended Interventions for Improving Workforce-related Outcomes ... 47
5.2.1 Design Features of Promising Synchronous, Blended Interventions ... 52
5.3 Summary ... 55

6. Recent and Emerging Trends in TBL ... 56
6.1 Improving Access To and Scalability of Learning ... 56
6.2 Individualization Through New Instructional Approaches and Data Analytics ... 59
6.3 Individual Engagement Through Entertainment and Active, Exploratory Learning ... 61
6.4 Facilitating Social Learning ... 63
6.5 Utilizing Data ... 66
6.6 Summary ... 68

7. Conclusion ... 69
7.1 Key Findings ... 69
7.2 Design Challenges ... 71
7.3 Research and Measurement Challenges ... 72
7.4 The Next Step ... 73

Works Cited ... 75

Appendix A. Documentation of Literature Search Strategy ... 91

List of Exhibits

Exhibit 1: Continuum of Technology Use 5
Exhibit 2: Highest Educational Attainment of WIA Participants Receiving Intensive or Training Services in PY 2012 15
Exhibit 3: TBL Programs Culminating in a Degree or Certificate 35
Exhibit 4: Rigorous Studies of Asynchronous, Technology-only Interventions (v. Traditional Interventions) 41
Exhibit 5: Rigorous Studies of Design Features of Asynchronous, Technology-only interventions 43
Exhibit 6: Rigorous Studies of Synchronous, Technology-only interventions (v. Traditional Interventions) 45
Exhibit 7: Rigorous Studies of Design Features of Synchronous, Technology-only Interventions 46
Exhibit 8: Rigorous Studies of Blended Interventions (v. Traditional Interventions) 48
Exhibit 9: Rigorous Studies of Design Features of Blended Interventions 54

Acknowledgements

This review of the literature on technology-based learning in workforce development and education was conducted under the direction of the Department of Labor's Employment and Training Administration. We are grateful for the guidance and support provided by our three project officers at ETA: Michelle Ennis, Richard Muller, and Charlotte Schifferes.

We also thank our Technical Working Group (TWG)—Dr. Mary Gatta, Dr. Rod Githens, and Dr. Shanna Jaggars—for their careful and thoughtful reviews of an early version of this monograph. We are also appreciative of the comments provided by our Federal TWG.

At MEF Associates, Mike Fishman and Asaph Glosser provided guidance, review, and feedback. We are grateful for the insights they provided throughout the development of this review.

List of Acronyms and Abbreviations

AE	Adult Education
AEFLA	Adult Education and Family Literacy Act
AJC	American Job Center
CTE	Career and Technical Education
DOL	U.S. Department of Labor
ED	U.S. Department of Education
ETA	Employment and Training Administration
ETPL	Eligible Training Provider List
ITA	Individual Training Account
LWIA	Local Workforce Investment Area
MOOC	Massive Open Online Course
NETP	National Education Technology Plan
NS	Not Significant
OCTAE	Office of Career and Technical Adult Education
OER	Open Educational Resource
OVAE	Office of Vocational and Adult Education
QED	Quasi-Experimental Design
RCT	Randomized Control Trial
SWA	State Workforce Agency
TAACCCT	Trade Adjustment Assistance Community College and Career Training
TBL	Technology-Based Learning
WIA	The Workforce Investment Act of 1998
WIB	Workforce Investment Board
WIOA	Workforce Innovation and Opportunity Act of 2014

Executive Summary

Introduction

Over the past decades, the rapid adoption and evolution of technology-based learning (TBL) has dramatically altered the landscape of education and training in the U.S and beyond. From its earliest incarnations as a form of remote or distance education, TBL has used advanced electronic or communication technologies to supplement and sometimes replace traditional (i.e., classroom-based) instruction. The field is now in the midst of a significant transformation to a new "generation" of TBL driven by near ubiquity of mobile technologies and social networking as well as by the increasing sophistication of the interactive and visual aspects of various learning systems and simulations. Collectively, these technologies have dramatically altered the reach, adaptability, and experience of TBL.

TBL has also been used to build various skills related to seeking jobs, employability, occupational preparation, basic literacy and use of technology itself. It has been used to extend such learning to a broader geographic population, reduce costs, and offer more individualized interventions adapted to individual learner's needs, learning styles, and interests.

This report, commissioned by the Employment and Training Administration (ETA) of the U.S. Department of Labor (DOL), focuses on understanding more about TBL, how it has been used for work-related skills and training, and whether it has been effective. We examine the literature on TBL interventions, factors associated with effectiveness, gaps in the knowledge base, and possible directions for future research.

The report begins with a conceptual overview of TBL and summarizes key strengths and limitations. This is followed by a chapter reviewing the factors that drive consideration and ultimately the adoption (or not) of TBL from the perspective of both the learner and the institutional provider. The next chapter reviews the public workforce, adult education, and career and technical education systems, highlighting how these systems' policies, priorities, and programs have shaped the TBL landscape. Next, the report explores the available rigorous effectiveness research to determine how effective TBL appears to be in achieving important workforce-related outcomes.[1] This examination of past TBL investments is followed by a chapter reviewing emerging technologies as well as the preliminary research on these technologies' effectiveness. The report concludes with a summary of findings, program design and research challenges, and possible areas for future research.

Conceptual Overview

TBL, or e-learning, broadly encompasses interventions that rely on advanced electronic or communication technologies to supplement or replace traditional (i.e., classroom-based) instruction. Over the past decades, the rapid evolution and increasing adoption of TBL has dramatically altered the landscape for workforce training and education. One notable turning point was the introduction of personal computing and the Internet, which allowed for standardization and increasingly widespread

[1] While the research questions of interest to this review focus on employment outcomes, no rigorous studies were identified that used more distal measures of employment and earnings. However, a number of studies were identified and reviewed that measured proximal workforce-related outcomes such as work-related learning, attitudes, and behaviors.

access to training and education. As noted above, a new "generation" of TBL is dramatically altering its reach, adaptability, and the user experience.

Due to both the diversity of technologies and breadth of applications, TBL does not have a single definitive characterization or definition. Rather, it is a continuum of interventions shaped primarily by how integral the technology is to the learning process. TBL models may rely entirely on technology for learning; may balance the use of technology and classroom learning (hybrid or blended models); or may incorporate some lesser use of technology into a predominantly classroom-based setting.

Considerations in the Use and Provision of TBL

The literature reveals an array of considerations that shape individual and institutional decisions to adopt and pursue TBL opportunities. On the learner side, recent data suggest that a portion of the U.S. adult population experiences difficulties in basic literacy and numeracy as well as technological literacy, in comparison to other industrialized countries. According to the Programme for the International Assessment of Adult Competencies (PIAAC), about one in six adults in the U.S has low literacy skills; nearly one in three has low numeracy skills; and nearly two in three have difficulty navigating technology-rich environments (OECD 2013). Low levels of literacy and numeracy are barriers to advancement in the labor market and entry into many occupational and educational programs, and TBL's role in building those basic skills is thus of obvious interest to policy-makers.

Low levels of basic skills could potentially affect the demand for TBL by moderating awareness, interest, and uptake. The much-discussed "digital divide" remains a barrier to access for part of the population, but it may be diminishing as mobile devices become universal and join desktop computers as a core delivery platform for TBL. However, the literature has not conclusively demonstrated the relationship between technological literacy or readiness for self-directed learning and TBL completion or success. Other factors also appear to be important for driving success in TBL, most notably how much of a social presence the TBL opportunity provides.

From an institutional perspective, the literature focuses more on the barriers to TBL creation, adoption, and use than on the factors promoting it (Parsad and Lewis 2008, Tabs 2003, Kotrlik and Redmann 2009). Institutional providers most often cited the cost of development (either from scratch or by repurposing existing materials) as the chief factor affecting their decisions to make TBL opportunities available. In procuring or adopting already-established TBL, some providers have been concerned about TBL quality and have demonstrated a level of skepticism about TBL equal to that shown by employers (Adams and DeFleur 2006). Another commonly cited barrier to TBL implementation is the time instructors need to gain familiarity and comfort with emerging technologies as well as to customize TBL materials for their learners and context.

TBL holds considerable potential for addressing challenges associated with workforce training and education. When considering implementation of a TBL resource, it is useful to consider how TBL addresses a number of challenges, including:

- Monitoring and assessing engagement and learning;
- Adapting learning to individual's needs;
- Modularizing learning to allow adults to focus on prescribed skills;

- Promoting motivation and interpersonal interaction;
- Using resources cost-effectively;
- Ensuring individuals have the appropriate supports for learning; and
- Assuring that the skills imparted are responsive to business and industry needs.

While these challenges are faced by traditional forms of instruction as well, they are uniquely complex when learners are remotely located, face-to-face interaction may be limited, and a critical threshold of "technological literacy" is needed to thrive. While TBL may present a number of unique challenges (e.g., the possibility of learner isolation), it also affords unique remedies (e.g., 24/7 access to personalized content). Ultimately, TBL is multifaceted and evolving, with strengths and weaknesses that vary by learning population, context, and content.

DOL Support for TBL in Workforce Services and Training

DOL has long supported the development, implementation, and evaluation of TBL in workforce training and education. This includes a multipronged effort to develop technological tools to aid jobseekers and to understand the role of technology in the workforce system, which is manifest in a national suite of services.

DOL has sponsored grants focusing on adoption of technology generally and administered the many grants funded under the $1.9 billion Trade Adjustment Assistance Community College and Career Training (TAACCCT) initiative. TAACCCT funded the development of TBL courses, programs, and tools for workforce training and supported an open online library called Skill Commons (https://www.skillscommons.org/) which includes workforce-related Open Educations Resources. ETA also conducted research under its TBL Initiative, provided policy guidance and technical assistance on the use of technology in the workforce system, and supported evaluation and research related to technology access within AJCs. This included surveys of state workforce agency (SWA) administrators and Executive Directors of Local Workforce Investment Boards (LWIBs) about the adoption of TBL strategies for training and employment services (Gan, et al., 2013).

Empirical Evidence of TBL's Effectiveness

A critical aim of this report is to synthesize findings from various evaluations that provide empirical evidence on the effectiveness of TBL for improving work-related outcomes, such as skill acquisition and employment. While there are few rigorous studies (randomized control trial or quasi-experimental design studies), some relatively recent studies compare work-related outcomes across TBL and traditional classroom instruction. Several themes emerged from these studies:[2]

- **Technology-only interventions that are not offered at particular times or places** (i.e., asynchronous), like standard online classes, vary from having negative to positive impacts on measures of workforce-related outcomes, including satisfaction, knowledge, and implementation of skills.

[2] Given the rapid evolution of technology, the literature search focused on findings from the past 10 years. However, studies are cited from as far back as 1994 if they are highly relevant or foundational.

- **Technology-only interventions that are offered at a fixed schedule and location** (i.e., synchronous), like streaming Webinars or moderated discussion groups, are more likely to be as effective as traditional interventions in affecting workforce-related learning (however, they are associated with some negative impacts on satisfaction, motivation, and attitude).
- **Blended interventions, which combine technology-based and traditional learning**, are likely to be as effective as traditional interventions in affecting workforce-related learning. Most are also likely to be as effective in increasing other workforce-related outcomes.

Across these three models of TBL, those that provide more opportunity for interaction (i.e., blended models) are more likely to have uniformly positive impacts than are those without interaction (i.e., asynchronous, technology-only). Additionally, the evidence suggests that impacts of technology-only interventions may be sensitive to "dosage" (i.e., amount of time learners spend in the intervention) and "locus of control" (i.e., active engagement with and learner control over content and practice work with feedback).

Recent and Emerging Trends

The relentless evolution of wireless technology, mobile communications, and social networking platforms has given rise to a whole new generation of TBL applications and opportunities. While the designs, applications, and products vary considerably, collectively they have dramatically altered the TBL landscape in the following ways:

- **Individualizing learning** by using artificial intelligence to create adaptive learning systems and Intelligent Tutoring Systems and by using technology to organize and implement modular, competency-based learning;
- **Enhancing learner engagement** by using game-based learning and immersive simulations that rely on engaging, incentive-based platforms as well as highly realistic learning settings to maximize engagement, time on task, and competency reinforcement; these also include use of three-dimensional and Augmented Reality technologies;
- **Promoting highly-interactive, social learning** by using Web 2.0, social media, and other collaborative approaches as a way to generate both the learning content and the learning environment (e.g., virtual worlds);
- **Mining data to shape learning opportunities beyond a given TBL application** by analyzing individual as well as "Big Data" to better understand the learning process and inform TBL design and synthesizing data to create transferable e-portfolios for learners to showcase their skills;
- **Improving access to and scalability of learning** by using Open Educational Resources and publically available instructional materials in conjunction with the increasing availability of mobile learning technologies and applications.

Overall, these emerging trends in TBL are highly interrelated and may ultimately enable new approaches to make instruction more accessible, individualized, and effective.

Recommendations from Key Findings

As policymakers, trainers, and educators analyze and monitor the ongoing evolution of TBL, several critical questions remain. TBL is complex and multifaceted and the inherent variations in technologies, communication and delivery platforms, and skill-building environments provide endless possible combinations of learning opportunities that must be examined within their own unique training contexts. Recognizing those varied contexts, this review identified approaches that need to guide effective TBL use:

- **Determine the proper balance between technology and "traditional" instruction in blended models**. The public workforce system, career and technical education providers, and adult education have all emphasized the use of blended instructional models, particularly as understanding of TBL has evolved. The exploration and evaluation of more complex blended models is particularly critical for occupational training, since the instruction must often integrate skill-building that is not easily adaptable to passive, technology-only education. This includes, for instance, clinical and lab-based skills in healthcare and hands-on repair in advanced manufacturing.
- **Design instruction that effectively addresses multiple dimensions of learner engagement.** Much of the research points to the importance of learner interaction and full learner engagement. Less than full learner engagement could contribute to isolation, "social loafing," attenuated skills development, and compromised outcomes. This multifaceted issue has implications for course design, instructional quality, choice and use of technology, and institutional support for learners. Each of these dimensions must be fully examined to determine their unique contribution to a productive learning engagement.
- **Integrate the perspective of employers**. Employers are critical stakeholders in the workforce development equation. What has yet to be determined is their level confidence when hiring external candidates whose preparation or certification has been achieved through exclusive or partial reliance on TBL. How this varies by occupation or experience level of the applicant is particularly important.
- **Target opportunities for standardized content and large-scale delivery.** The public workforce system remains committed to seeking increasingly cost-efficient developmental and delivery options. To these ends, future initiatives should fully explore the feasibility of using more "off the shelf" content available through third-party developers, such as publishers, curriculum designers, equipment makers, and industry associations. When delivered at a large-scale, TBL could cost-effectively expand the reach and capacity of the public workforce system. Targeted research is needed to identify appropriate content, examine logistical feasibility and confirm the potential to achieve critical outcomes.
- **Further explore the addition and substitution of technology.** Some preliminary evidence suggests that "dosage matters" and that the addition of technology to traditional instruction generally yields positive results. Is it simply that "more content is better" or does technology play some role? Curriculum designers must also understand how to balance the trade-offs between TBL and traditional instruction, in order to most cost-efficiently achieve a standard result (e.g., competencies needed to pass a certification exam).

- **Provide effective professional development and support for training providers**. The literature suggests the access to and value of TBL is partially dependent on the readiness of those procuring TBL and training and educational providers to assess, recommend, and facilitate engagement among learners. Maintaining this staff readiness is particularly critical given the rapid evolution of technologies and TBL options.

1. Introduction

Over the past decades, the rapid adoption and evolution of technology-based learning [3] has dramatically altered the landscape of education and training in the U.S and beyond. From its earliest incarnations as a form of remote or distance education, TBL has involved advanced electronic or communication technologies to supplement and sometimes replace traditional (i.e., classroom-based) instruction. The field is now in the midst of a significant transformation to a new "generation" of TBL driven by near ubiquity of mobile technologies and social networking as well as by the increasing sophistication of the interactive and visual aspects of various learning systems and simulations. Collectively, these technologies have dramatically altered the reach, adaptability, and experience of TBL.

TBL has been used for many years to build occupational skills, extend such learning to a broader population, reduce costs, and offer more individualized interventions adapted to individual learner's needs, learning styles, and interests. The critical importance of technology in the workforce system was given renewed emphasis in the major authorizing legislation for the workforce system, the Workforce Innovation and Opportunity Act of 2014 (WIOA), enacted on July 22, 2014. WIOA is administered by ETA at the Federal level and implemented by state and local workforce development boards (WDBs) and agencies, and a nationwide network of American Job Centers (AJCs). Under WIOA, both state and local boards have responsibilities for developing strategies to use technology for a broad array of purposes. These include using technology to maximize the accessibility and effectiveness of the workforce system for employers, workers, and job seekers. Goals for such technology use include enhancing digital literacy skills; accelerating learning and attainment of recognized postsecondary credentials; and ensuring access to individuals with disabilities or who live in remote areas.

This report, commissioned by the Employment and Training Administration of the U.S. Department of Labor, focuses on understanding more about TBL, how it has been used for work-related skills and training, and whether it has been effective. We examine the literature on TBL interventions, factors associated with effectiveness, gaps in the knowledge base, and possible directions for future research.

ETA has had a long-standing interest in the use of technology in the workforce system and its instrumental role in the development of a host of electronic tools and systems relating to accessing information on jobs, job search, career paths, occupational skill requirements and workplace competencies, and educational and training resources (DOL, ETA 2014).

During the mid-2000s, ETA further extended its commitment to understanding and promoting the use of technology through the TBL Initiative. Under that initiative, the agency conducted a survey on TBL, sponsored demonstration grants, provided policy guidance and technical assistance on the use of technology in the workforce system, and supported other research related to technology access and use within workforce system. Under a current effort, ETA is again researching how TBL is used in various parts of the workforce system.

---

[3] Other common terms include, but are not limited to, computer-aided instruction, computer-assisted instruction, computer-based instruction (CBI), computer-based training (CBT), computer managed instruction, cyber-learning, digital educational collaboration, Internet-based training (IBT),information and communication technology (ICT) based learning, m-learning, multimedia learning, online education, technology-enhanced learning (TEL), Web-based training (WBT), virtual education, and virtual learning environments (VLE).

ETA continues to oversee grants funded under the $1.9 billion TAACCCT initiative, which has resulted in the creation of a huge array of TBL courses, programs and tools, which are housed in an open online library, SkillsCommons found at: (https://www.skillscommons.org/).

The appeal of using TBL to address skill needs has received new urgency since recent reports have shown that, compared to workers in other countries, a significant portion of U.S. workers fare poorly on basic literacy and numeracy. According to the Programme for the International Assessment of Adult Competencies, about one in six adults in the U.S has low literacy skills; nearly one in three has low numeracy skills; and nearly two in three have difficulty navigating technology-rich environments (OECD 2013). These relatively low levels of competencies likely pose significant challenges for advancement in the labor market and improving those skills is one of the key challenges facing the public workforce and adult education systems.

One major aim of this review is to address the question "What is the empirical evidence regarding the success of TBL in building work-related skills and in increasing employment and earnings of workers?" In addition to this primary mission, the review will also help to identify trends in the development of TBL as well as "gaps" in the research and the questions that remain. Identifying these gaps is particularly important in this expanding field, where comparatively little has been systematically and rigorously evaluated, particularly as it relates to workforce-related training, education, and employment outcomes. The report concludes with a discussion of possible areas for research, pilot, or demonstration projects "on the use of technology for training, employment-related education, and access to employment services for key target groups [such as economically disadvantaged adults, dislocated workers, and veterans] served in the public workforce system" (DOL 2013).

1.1 Organization of the Paper

The key topics of the literature review are summarized below.

- **Concepts and contributions.** To establish a common understanding, Chapter 2 provides an overview of key features and operating dimensions that define TBL. This is followed by a general summary of both the potential benefits of TBL and its limitations and challenges.
- **Considerations in adoption.** A variety of factors shapes the demand for and decision to adopt TBL to support workforce training and education. Chapter 3 examines these considerations from several relevant perspectives. First, and most important, are factors that appear to shape the decisions of individual learners within the workforce system: their skills and competencies; challenges to learning; technological readiness and access; psychological factors; and supports for engaging in TBL. This is followed by a review of issues that shape providers' decisions to use TBL as developers, procurers, and implementers. Effective TBL, in any context, should account for the confluence of factors related to both the learners and providers.
- **Prevalence and use for workforce development and education.** Chapter 4 narrows the discussion from TBL in general to the use of TBL for workforce development and education. It begins by describing the learners engaged in workforce development and education who are the potential users of TBL. It then describes TBL within the public workforce system under DOL's stewardship. The discussion focuses on the TBL Initiative, targeted grants, programs, and policies as well as recent research examining the current use and prevalence of TBL. The chapter closes by discussing the emphasis on and support for TBL within other contexts for workforce training

and education: career and technical education and adult education, as well as within developmental education courses.

- **Evidence of effectiveness.** Chapter 5 reviews rigorous impact evaluations to identify empirical evidence related to the effectiveness of TBL for improving work-related skills that may eventually lead to increases in the employment and earnings of workers. The chapter examines the evidence related to TBL effectiveness for workforce development, focusing on impacts on employment-related outcomes, behaviors and satisfaction, learning gains and skills acquisition.[4]
- **The (near) future of TBL.** The review concludes with an eye to the future. Chapter 6 describes the current trends in TBL and promising areas for future expansion. With TBL's strengths, responses to its past challenges, and the prevalence and availability of online and Web-based technologies, the adoption and use of technology in learning is growing rapidly. The chapter describes key trends in TBL and, where possible, preliminary evidence related to their promise.

1.2 Methodology

TBL is a far-reaching, multifaceted, and rapidly evolving approach to pedagogy and learning. As such, preparing this literature review has focused on broad trends but also required setting and adhering to some "boundaries" to maintain both focus and relevance (See Appendix A for the literature search strategy). To address DOL's priorities and areas of interest, this review draws on literature that broadly emphasizes the use of TBL for supporting the development of work-related skills and increasing employment and earnings of workers. This includes literature on the use of TBL in providing the following:

- Initial career and technical training as related to occupational skills;
- Work readiness, job search, and developmental "soft" skills training that enhance employability;
- Services to at-risk adult populations with significant basic skill deficits

While these priorities cannot provide precise boundaries for the literature review, they do serve to maintain an emphasis on the workforce development challenge. At the same time, they establish an important distinction from the significant body of literature that addresses the use of TBL in traditional K-12 or academically focused post-secondary education.

In addition to these broad parameters, the preparation of this report required decisions about the types of literature to be cited as evidence of TBL effectiveness or promise for workforce development (Chapter 5). A major, but not the sole, emphasis is on rigorous impact evaluations, that is, randomized control trials and quasi-experimental design studies. The level of internal validity associated with these designs is high, lending credence to the findings from these studies.

However, it should be noted that there are relatively few rigorous studies using random assignment or quasi-experimental methods. Several unique factors may have inhibited wider use of rigorous methods to evaluate the use of TBL for workforce development. First is the rapid and ongoing pace of change in the field of TBL. Specific technologies, platforms, investments, and commitments may have shifted, advanced, or become obsolete well before a comprehensive study could be contemplated, let alone

4 As will be discussed later, no studies that measure the ultimate outcomes of interest (e.g., employment and earnings) were identified.

completed. At the same time, the specter of constant change may have further constrained the level and scope of necessary research. Also complicating the equation is the importance of examining longer-term outcomes in regard to workforce development, such as earnings, job retention, job stability, and continuing education which are difficult and time-consuming to track, and are rarely the subject of the available studies. In light of these constraints, the inclusion criteria for research on current trends in TBL (in Chapter 6) is relaxed slightly to include any effectiveness study, including pre-post and outcomes-only (or post-post) comparison group designs.

To be referenced in this review (in either Chapter 5 or 6), the studies must provide insight into the effects of TBL. Because rigorous evidence on the workforce outcomes is not currently available, the review considers posited proximal outcomes, like skills or knowledge accumulation, learner satisfaction or experience, and behavioral changes related to work. Further, to be cited, the reviewed studies had to examine TBL interventions among samples of learners that are broadly comparable to the populations commonly served through the public workforce system. Thus, the emphasis is on adults enrolled in two-year colleges, adults receiving services through the public workforce system, adults in continuing or remedial education, and incumbent workers looking to advance along a career pathway.

These broad guidelines are applied with a degree of flexibility to maximize the utility and applicability of this review.[5]

[5] For example, Chapter 4 discusses data on the prevalence of TBL within all institutions of higher education, even though some may include “traditional” college students who are less likely to use the public workforce system.

2. Technology-Based Learning: Basic Concepts, Strengths, and Limitations

TBL is learning that takes place partially or entirely via electronic technology. This includes online and Web-based education, Intranet sites, audio- and video-conferencing, Internet chat rooms, simulations, electronic gaming, CD-ROMs, and a variety of mobile options (Carruth and Carruth 2013; Gan et al. 2013; Maxwell et al. 2013; Koller, Harvey, and Magnotta 2006; Pantazis 2002). This chapter introduces several key concepts intended to establish a common understanding of what TBL entails and factors that underlie its importance. It then describes the strengths and challenges associated with TBL as compared to "traditional" classroom learning.

2.1 Review of TBL Concepts

Due to both the diversity of technologies and breadth of applications, there is no single definitive characterization or definition of TBL (Dunham et al. 2011; Gan et al. 2013; Koller, Harvey, and Magnotta 2006; Maxwell et al. 2013; Carruth and Carruth 2013). This section synthesizes the leading definitions in the literature to provide a basis for further examining the use of technology for learning. Briefly, the simplest and most commonly used way to characterize TBL models is by how integral the technology is to the learning process: TBL models may rely entirely on technology for learning; may balance the use of technology and classroom learning; or may incorporate some lesser use of technology into a predominantly classroom-based setting. Then, within this continuum, TBL models are characterized by how technology structures the learning process over time and space. Finally, other more advanced characterizations of TBL are considered. While many of these dimensions often overlap, each distinctly defines variations in TBL models and has important implications for learning.

2.1.1 A Continuum of Technology Use

At its most basic, TBL can be characterized by the degree to which technology is the primary source for learning. This is the most common characterization of TBL in the literature. In this simplified conception, one can imagine a continuum of models based on the relative amount of technology used (Exhibit 1).

Exhibit 1: Continuum of Technology Use

From a definitional perspective, a learning model in this review is characterized as technology-only, blended, or traditional based on the proportion of learning that depends on technology (Dunham et al. 2011).

- At one extreme is **technology-only learning**, in which electronic technology is the medium for all learning and teaching. A typical example is a completely online, self-paced course.
- At the other end is **traditional**, in which neither instructor nor learner uses technology. A traditional, in-person, instructor-led, paper-based classroom is the archetype.

- Between the extremes of technology-only and traditional classroom-based models are **blended**, or hybrid, models. Blended models, which represent the dominant paradigm in TBL, are those where instruction is delivered both using technology and in a traditional classroom.

In the literature, technology-only, blended, and traditional approaches are not discrete categories but rather points along a continuum (e.g., Gan et al. 2013; Arbaugh et al. 2010). Further complicating the definitions, models often are categorized on the basis of how content is delivered (rather than received) and the boundaries between technology-only and blended vary within the literature. For example, experts vary in their characterization of online learning models, which are often synonymous with technology-only approaches, based on the amount of instruction delivered online. Quantifying the amount of content transmitted or delivered is a simpler measurement task than quantifying the most-effective media for that content (i.e., the learning). A national survey of online courses in post-secondary institutions defined technology-only courses as those in which instruction was entirely online; blended courses were those in which any combination of online and classroom instruction was used and the use of technology reduced seat time (Parsad and Lewis 2008). In contrast, Arbaugh et al. (2010), which reviews 15 years of research on online and blended learning in the management discipline, defines technology models as those with at least 80 percent of content and activities delivered online and blended models as those that have between 20 and 79 percent of content and activities delivered online.

These distinctions between the mixture of technology-based and traditional instruction also underscore other critical distinctions in TBL models, namely how learning is distributed across time and space. These two characteristics are often, but not always, collinear (see insert).

TBL models where the majority of learning is designed to occur within specified blocks of time are defined as synchronous.[6] In these designs, the instructor and learner(s) are physically or virtually face-to-face (Dunham et al. 2011; Maxwell et al. 2013). Like traditional learning models, TBL courses and programs that are structured primarily around classroom time or computer lab time where instructors connect "live" (e.g., using Skype or a commercial learning management system platform) are considered to be synchronous. Online courses in which learners watch instructors on real-time video feeds are also synchronous. In blended synchronous courses teachers may simply use computers to supplement and enhance instruction (e.g., Computer-Assisted Instruction). Asynchronous models, on the other hand, are those where learning is not constricted by time or place. A prominent example is distance education, which has been around since the 1700s (Harting and Erthal 2005). Distance education began as correspondence education where content was delivered to homes via postal mail. Today, mobile and Web-based technologies enable distance education via more rapid delivery and accessibility of content to even more remote and dynamic locations. From anywhere with Internet access, learners can log into the courses, access course content, and interact with other learners asynchronously. Massive Open Online Courses (MOOCs) in which instructional videos are recorded and uploaded to a course Web site are examples of asynchronous TBL.

---

[6] Technically "synchronous" is derived from the Greek word for time, "chronos." Some authors separate time and space, characterizing TBL across space as "place-dependent" and "place-independent" (e.g., Visser and Visser-Valfrey 2008; Vihtonen and Ageenko 2002). However, given the common overlap between time and space in TBL, this literature review follows most research in collapsing the time and space dimensions under the headings "synchronous" (same time and/or place) and "asynchronous" (different time and/or place).

2.1.2 Advanced Forms of TBL

The rapid evolution of technology coupled with a more sophisticated understanding of learner needs has led to advanced dimensions of TBL that extend beyond basic instruction and content delivery. Technology, in particular, has the potential to extend pedagogy through its ability to facilitate learners' interaction with the content and to individualize content. In addition, it has the potential to change the ways in which learners interact with other learners and instructors.

Traditional passive learning primarily relies on static content versus active learning engagement that ideally uses flexible material shaped by the needs of the individual learner. Early distance learning opportunities were famously passive with the technological component often limited to reading on a computer monitor rather than a book. As communications technologies and delivery platforms evolved, so did the opportunities for more active learning that allowed for applying knowledge, solving problems, practicing skills, and receiving feedback on progress. TBL may focus learning on the content (as in early online courses) or on the learner by individualizing content. Below are some of the ways, described in Means, Bakia, and Murphy's (2014) review, in which TBL may be designed to meet the needs of less-prepared adult learners:

- Use of spaced, quick assessments of learning and cumulative, comprehensive examinations;
- Including practice assessment items that require students to generate answers and provide feedback as quickly as possible;
- Providing feedback that addresses the nature of a student's misunderstanding and include tips for remediation; and
- Applying the "Goldilocks" principle in selecting [just the right] problem difficulty.

For instance, non-linear TBL techniques seek to more fully engage students by attempting to inject an element of "spontaneity," personal preference, and interest into the process. The use of hyperlinks in Web-based content is a ubiquitous example of this strategy. More sophisticated tools are designed to give students "multiple opportunities to comprehend a given subject; the student may vary his or her learning activities based on individual preferences, skill levels and educational needs" (Benchmark Learning n.d.).

Clearly these advances in technology have generated a rich set of diagnostic, teaching, learning, and delivery opportunities that extend well beyond original distance learning components. Despite these advances, however, one common ongoing consideration spans the evolving field of TBL: the role and intensity of interpersonal support. Whereas interpersonal interaction is largely a given within traditional, blended, and synchronous models, TBL varies in its inclusion of interpersonal interaction and support, with additional challenges to interaction within asynchronous or technology-only models.

The TBL literature is largely unambiguous, however, about the importance of interaction, both among learners and between learner and instructor (Abrami et al. 2011; Bernard et al. 2009; Dunham et al. 2011; Sher 2009; Woods Jr. and Baker 2004). In their report on DOL's TBL training programs, Dunham et al. (2011) found that "effective communication and interaction among participants and between participants and their instructors was considered an important pedagogical practice by instructors across multiple TBL programs." Thus, a major criticism of TBL is the absence of face-to-face interaction between the instructor and learners such that learning is impeded (Sher 2009). Means, Bakia, and Murphy (2014) point to the following two ways in which TBL may meet the needs of less-prepared learners:

- Harness the power of peer-to-peer collaboration and
- Create a sense of instructor presence and responsiveness.

Instructional designers of TBL have taken steps to ensure not only that interaction is possible, but also that technology can be used to facilitate and even enhance interaction. Social learning is an outgrowth of the explosion of social media platforms for communication and interpersonal engagement (Benchmark Learning n.d.). Through such tools as blogs, chat rooms, Wikis, and discussion groups, the learning process can readily become more collaborative, more interactive, and more capable of addressing learner needs in "real time" (ibid). Similarly, synchronous online discussion forums, e-mail and blogging applications, the use of Skype and other video conferencing tools, and virtual worlds are all examples of how technology can be used to facilitate and enhance collaboration and interaction between learners and instructors and between learners and other learners.

2.2 Overview of Strengths and Limitations of Using TBL

Underlying the development and diversity of TBL are core considerations related to the effectiveness of learning, the delivery of learning opportunities, and access to such opportunities. This section discusses the strengths and limitations of TBL in broad terms as it has evolved in the 21st century. This discussion is organized around a host of factors including TBL's inherent capacity for monitoring learner engagement; adapting learning to the needs of learners; promoting interpersonal interactions; promoting cost savings; and enhancing access and learning readiness.

Before delving into these factors, it is useful to note five overarching issues central to understanding how and where these strengths and limitations apply:

- **TBL is varied.** As noted earlier, "technology-based learning" is an extremely broad "umbrella" term that encompasses multiple technologies, applications, instructional strategies, learning platforms, and infrastructure needs. As such, gauging the inherent strengths and limitations of TBL must rather account for this significant diversity.
- **The learning context matters.** For instance, the flexibility and convenience afforded by online and Web-based technologies may increase accessibility to instructional content and learning for working adults who have significant constraints on their time. Conversely, they may be less important in a K-12 classroom context.
- **There is a duality to the strengths and limitations of TBL.** For instance, online and Web-based education allows learners the flexibility to access learning content from home and at their own pace. However, that flexibility also may be associated with isolation that can detract from personal interaction and engagement with the content. In one study, participants reported that the use of laptop computers allowed for flexibility in both time and place, but participants also noted that too much independence could prove problematic; some structure ensured that they remained on task (Gatta 2005).
- **Some considerations may be in conflict**. Reconciliation or balancing of conflicting considerations may be part of the adoption decision. For example, a more accessible and less expensive modality like an online course may be associated with weaker knowledge and skill retention or higher rates of learner attrition than in traditional programs. How TBL programs and

courses use available technologies and negotiate their strengths and limitations contributes to their effectiveness.

- **TBL is rapidly evolving.** Much like the mobile and Web-based technologies on which they are built, TBL applications and platforms are evolving at a very rapid pace. As such, any discussion of the strengths, limitations, and challenges of technology-based learning must readily acknowledge that the analysis is of a quickly moving target. In this spirit, some of the issues raised below will be further addressed in Chapter 6, which summarizes emerging trends in technologies and applications.

2.2.1 Monitoring and Assessing Learner Engagement Remotely

The biggest challenge for TBL is related to delivering the quality and effectiveness of instruction and the related challenge of maintaining the necessary level of learner engagement. The literature consistently finds evidence of low learner engagement in TBL. Learner drop-out, low effort, or "social loafing"; cheating; as well as learner isolation are real and common concerns for TBL (e.g., Gan et al. 2013; Carruth and Carruth 2013; Moody 2004). Thus the use of technology may present challenges to, as well as facilitate, learner engagement, and ultimately, the instructional effectiveness of TBL.

One common hypothesis about instructional effectiveness supposes that learners are more engaged if they are monitored and accountable for their learning (Dunham et al. 2011). This seemingly perennial concern with TBL is closely associated with asynchronous education models in which teachers cannot "see" learners. Monitoring learner attention and effort, which is done easily in a classroom setting, is much more difficult remotely and asynchronously. The online environment limits opportunities for supervising, tracking, and verifying learner progress (Carruth and Carruth 2013). Without such active management, learners are more apt to become disengaged (Gan et al. 2013; Koller, Harvey, and Magnotta 2006; Dunham et al. 2011; Carruth and Carruth 2013).

In response to these concerns, course designers and instructors have begun using technology to overcome issues of low learner engagement. Learning Management Systems can now track how long a learner spends on specific tests or even individual test questions (Dunham, Estrella, and Nyborg 2010). Technology more generally allows for easy collection of data for monitoring both learner engagement and progress.

A related concern is that it is easier for learners to cheat on TBL assessments, since they can bring in outside resources or test-takers without detection (Dunham et al. 2011). Again, this is particularly of concern for asynchronous assessments. However, technology is being used to mitigate these concerns in some contexts. For example, within an online course, innovators are producing methods and implementing techniques such as keystroke biometrics to identify learners, requiring them to present an ID before they take a test, and using virtual camera monitoring (Carruth and Carruth 2013).

2.2.2 Adapting Learning to Individuals' Needs

A related challenge to instructional effectiveness posed by TBL can be the consistency and lack of individualization. On one hand, prerecording lessons provides a greater level of control over what content is being delivered; thus, a higher level of consistency (and potentially quality and efficiency) exists across multiple instructors involved in the content delivery (McDonald and Smith 2013). However, the uniformity of this content-centric TBL may also raise challenges in delivering material to a diverse group of learners. Whereas a traditional classroom allows for feedback from responsive instructors, content-centric TBL is limited to delivering pre-recorded or programmed material. Not only can these forms of TBL not monitor learner engagement, they also may not be able to monitor and respond to learner questions or their variable levels of comprehension, interest, or needs.

On the other hand, technology may also offer the unprecedented opportunity to contextualize and individualize instruction and learning content (Gan et al. 2013; Allen and Seaman 2011; Maxwell 2012; Roy and Raymond 2008; Kidd 2010). In technology environments, each learner can:

- Repeatedly access and reflect upon content they find challenging;
- Receive content in a variety of formats to fit their needs, including text, audio, and video;
- Interact with and even create learning material (e.g., through discussion forums, Wikis, and other Web 2.0 technologies); and
- Receive individualized assistance based on emerging “digital tutors” that are incorporated into some learning systems.

While learners new to this approach often require more guidance (Huang 2002; Kirschner, Sweller, and Clark 2006), research suggests that some learners can benefit from more autonomy and individualization. This is particularly true for adult learners since most are voluntary participants in their learning, so the “motivation to engage is a cognitive disposition that learners bring with them when they enroll in adult literacy classes” (Beder et al. 2006, p. 119, as cited by Miller 2010).

Moreover, data mining and adaptive software technologies can automatically tailor practice problems and other learning content to the learners’ needs (Russell, Lippincott, and Getman 2013). For instructors, online TBL enables continuous updates and expansion of content as dictated by learners’ needs and/or preferences.

As a result, learner-centered TBL models enable a more content-flexible approach to learning (Maxwell 2012). Ultimately, learner-centered TBL models, in which content is flexibly driven by individual needs and interests, are consistent with constructivist learning pedagogy. Learning may be customized to best suit individual’s learning styles, basic skills, and interests. These models—which may be learner- or instructor-driven—encourage active, participatory learning in which individuals construct their own knowledge (Koller, Harvey, and Magnotta 2006).

Arguably the biggest advantage associated with asynchronous TBL models, especially for workforce training programs, is the time and space flexibility that they afford learners. There is no shortage of research on the promise that this flexibility and convenience holds for working, low-income, or unemployed adults and parents, for those in remote places where in-person training (or transportation thereto) is not feasible, and for those with physical disabilities (Russell, Lippincott, and Getman 2013; Koller, Harvey, and Magnotta 2006; Moody 2004; Gan et al. 2013; Gungor and Prins 2011; Dunham et al. 2011; Githens et al. 2012; Maxwell 2012; Allen and Seaman 2011; McCain 2009). Further, emerging trends such as mobile learning are making this “anytime anywhere” learning even more of a reality.

2.2.3 Promoting Interpersonal Interaction

Particularly in asynchronous TBL models, program designers and instructors may find it challenging to incorporate adequate substitutions for learner-to-learner and instructor-to-learner interactions and collaboration (Maxwell 2012; Dunham et al. 2011; Roy 2010; Ke and Kwak 2013). Research suggests this is a crucial part of the learning process, especially for adults (Angelino, Williams, and Natvig 2007; LeNoue, Hall, and Eighmy 2011; Snyder, Jones, and Bianco 2005). For instructors, it may be more difficult to develop rapport with learners or gauge whether they were able to understand course lectures (Dunham et al. 2011). In some instances, the use of technology may result in learners' feeling isolated, disconnected, and unsupported.

However, technology may also increase interpersonal interaction. Blended models may represent useful options because they offer opportunities for synchronous interaction. Alternatively, some TBL programs are incorporating technologies that can themselves facilitate or at least allow for effective communication and interpersonal interaction within both blended and technology-only courses. For example, Web 2.0 technologies, online and video discussion forums, virtual technologies, and other tools can provide a platform to develop and promote interaction and collaborative learning communities (Dunham et al. 2011; Maxwell et al. 2013; Moody 2004; McCain 2009; McKay and Izard 2012; Ke and Kwak 2013; Walsh et al. 2011). Instructors can scaffold or support interactions via asynchronous feedback or synchronous video-conferencing with multiple participants (Ke and Kwak 2013; Dunham et al. 2011; Roy and Raymond 2008). In the workplace, Intranet and chat forums can facilitate the distribution of ideas and practices across an organization (Rossett and Marshall 2010). Finally, incorporating learning communities in TBL courses can, in addition to fostering collaborative learning, also help overcome learners' feelings of disengagement with online courses (Angelino, Williams, and Natvig 2007; Moody 2004).

2.2.4 Saving Costs and Resources

The associated time and resource costs are major considerations for adopting and implementing TBL. These costs may be associated with such things as developing content; integrating technology and content; programming; training instructors; and supporting implementation of the necessary technology, personnel, and infrastructure. For the workforce system in particular, Gan et al. (2013) finds that one of the biggest concerns with or barriers to implementing TBL are the costs. These costs become more burdensome the more TBL seeks not just to broadcast and archive content and materials delivered in traditional classes (e.g., a pre-recorded Webinar that can be accessed asynchronously), but to engage learners more actively. In these instances, instructors often need more time, training, and support to use technology effectively and to keep their learners engaged (Bowen and Ithaka 2012; Maxwell 2012; Roy 2010).

Related cost concerns are those associated with hosting or accessing content. Technology requires infrastructure (e.g., computer labs, broadband access). In the workplace setting, employers may incur additional costs in establishing the technological infrastructure for networking and collaborative workspaces (McKay and Izard 2012). Similarly, the workforce system may bear the costs of adopting and maintaining the infrastructure necessary to support effective TBL.

However, once the technological infrastructure is established and instructors are familiar with the tools and effective TBL instructional methods, a significant strength of TBL is its scalability or the relatively low marginal cost of delivery (Bowen and Ithaka 2012; DOL 2008a). Once developed, TBL learning materials can easily and efficiently be reproduced, updated, and streamlined (Koller, Harvey, and Magnotta 2006). These savings are especially pronounced for remote populations of learners that were previously (especially geographically) unreachable (Maxwell 2012; Carruth and Carruth 2013; Koller, Harvey, and Magnotta 2006). For training providers, TBL can save on course fees, transportation, meals, lodging, time away from work, training (workers) and retraining (instructors) time, and time for distribution of learning materials (Roy and Raymond 2008; Pantazis 2002). Additionally, cloud technology offers a potentially cost-saving alternative to supporting a local infrastructure of servers and services (Russell, Lippincott, and Getman 2013). With cloud technology, materials and course infrastructure can be uploaded and reliably stored and accessed from anywhere via a secure connection (Boja, Pocatilu, and Toma 2013; Hignite, Katz, and Yanosky 2010).

2.2.5 Strengthening Access and Readiness

Another set of issues is related to effectively supporting the technological access and readiness of learners. While online technologies have made basic education and training more accessible to adults, a “digital divide” mitigates this access for many people. The “digital divide” most commonly refers to a difference in access to technology (i.e., those who have it and those who do not) (Gungor and Prins 2011; Russell, Lippincott, and Getman 2013; Moody 2004; Warschauer and Liaw 2010). However, it can also refer to a difference in *accessibility* or the difference in technological “literacy” between those who use technology regularly (“digital natives”) and those who do not (“digital immigrants”) (Hughey and Manco 2012; Bynner, Reder, and Parsons 2010).

This issue exists for both learners and instructors. The impact of learners’ technological access and readiness is relevant to all forms of TBL. The impact of instructors’ access and readiness is slightly less pervasive, but impacts any TBL that requires personal interaction between the TBL and the learner. Using TBL effectively may require not just technology support, but also instructors effectively using and interacting with the TBL product or curriculum so they can guide learners through the materials and complement the TBL (Carter and Titzel 2003). Learners and instructors with low technological literacy and comfort levels often become frustrated trying to use the technology (Maxwell 2012; Hughey and Manco 2012; Moody 2004) or when they encounter technical difficulties (Moody 2004; Koller, Harvey, and Magnotta 2006; Sitzmann et al. 2010). Instructors, as well as learners, frequently feel challenged without adequate training or support (Roy 2010).

To deal with these issues, some programs provide initial training support (e.g., orientations, assistants, courses) to familiarize instructors and learners with the technology or to impart effective technology-based pedagogical practices to the instructors (Dunham et al. 2011; Sitzmann et al. 2010; Maxwell et al. 2013). For learners with learning and physical disabilities, TBL programs offer a variety of assistive technology options. For example, programs may provide screen readers and closed captions for online videos (Dunham et al. 2011; Betts, Cohen, et al. 2013). Screen readers, such as iPhone’s VoiceOver or Android 4.0’s TalkBack, are used by individuals who are blind or have learning disabilities (e.g., dyslexia, dysgraphia, attention deficit disorder) (Betts, Welsh, et al. 2013).

2.3 Summary

TBL is a broad category encompassing numerous technologies, applications, instructional strategies, and platforms used for learning. Initially, TBL focused on making curricula and materials more widely available through the use of technology (e.g., posting class materials online), but later iterations use technology to change the learning process itself. Today, in addition to whether, and to what extent, technology-based delivery is blended with more traditional instruction, TBL varies in whether learning is bound by time and space, in how actively individuals “drive” their learning process, and the extent to which learning is social or interactive.

The literature highlights challenges common to every form of education. These include concerns about learner engagement, meeting the needs of individual learners, encouraging cooperative learning, efficient resource allocation, and ensuring individuals are supported in their learning. The technology-based environment has added a level of complexity or uniqueness to each of these the challenges and concerns. For example, learners may need additional support with technological literacy before they can begin to use TBL. At the same time TBL, particularly as it has evolved more recently, has also provided unique opportunities to address these challenges. For example, user-friendly and intuitive applications and open educational resources built into more readily accessible technology (e.g., smartphones) may increase access to learning. Another example of TBL's strengths is how it leverages data and faster computing may allow for empirically based individualization of learning content and processes. Ultimately, TBL is multi-faceted and evolving, with strengths and weaknesses that may vary by learning population, context, and content.

3. Considerations for Using and Providing TBL

To provide context for assessing the current and potential role of TBL for workforce training and education, this chapter delves more deeply into factors that ultimately shape its availability and productive use. Specifically, the discussion examines the myriad factors that need to align for institutions to introduce TBL opportunities and then to have them fully considered and adopted by users.

The chapter first characterizes the learners typically engaged in workforce training and education, and then examines the extent to which various learner characteristics, including psychological and preparedness factors, shape the TBL experience. The subsequent section reviews various institutional considerations that shape providers' decisions to invest in and offer TBL. Provider considerations are subdivided into the related factors affecting the development, procurement and implementation of TBL. Ultimately, an understanding of these learner and provider considerations sets the stage for broadly understanding the dynamics of adopting and using TBL for workforce training and education.

The empirical literature underlying the discussion in this chapter is based largely on self-report surveys or correlational analyses designed to generate insight into factors that shape TBL adoption and use and the TBL learning experience.

3.1 Learner Considerations

Understanding factors affecting learner engagement and success with TBL requires some insights into the learners in the public workforce system and their general levels of educational preparedness. In particular, this section focuses on the following key factors related to successfully engaging adult learners in TBL:

- Heterogeneity of basic skill levels within the public workforce system population
- Low levels of technological literacy within the U.S. adult population
- Challenges related to the digital divide
- Learners' psychological readiness and characteristics
- The importance of external supports

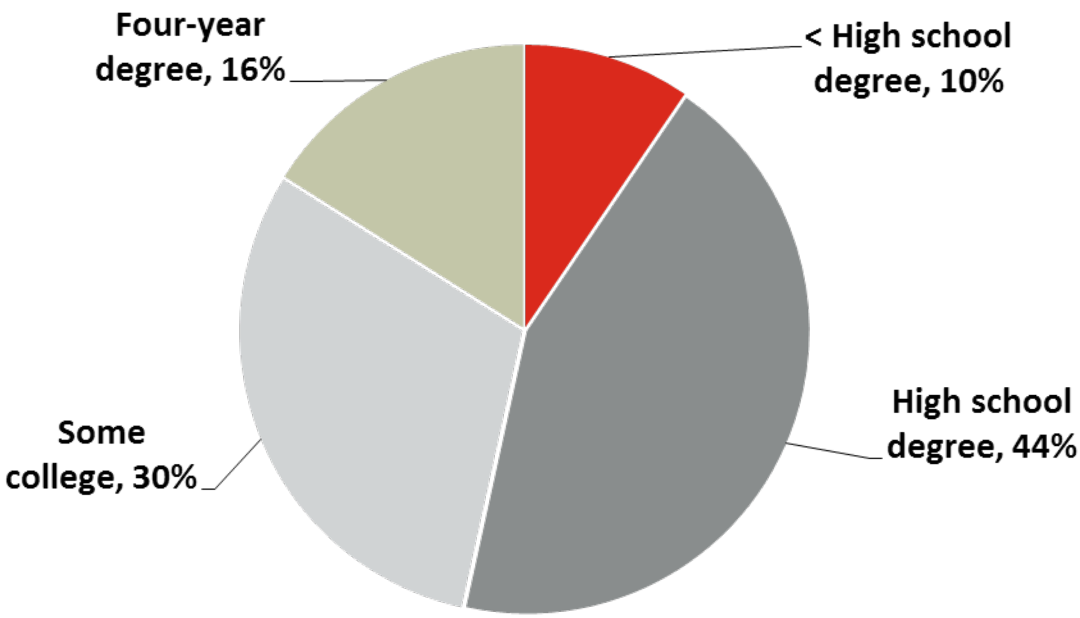
3.1.1 Basic Skills

Learners' basic skills and knowledge levels may require additional supports to engage with occupational or soft skills development, whether the mode of learning is traditional or technology-based. This is particularly true for the public workforce system, which tends to emphasize providing services to those facing educational deficits or related barriers to employment.

Information from workforce system data under prior law, Workforce Investment Act Standard Record Data (WIASRD), provides a comprehensive portrait of the population served by the public workforce system. Focusing on exiters from WIA Title I Programs, a total of 1.93 million people participated in the programs in Program Year 2012 (April 1, 2012 through March 31, 2013), which includes adults (1.1

million participants), dislocated workers (705,706 participants), and youth (112,386 participants) (Social Policy Research Associates 2013).[7]

Exhibit 2: Highest Educational Attainment of WIA Participants Receiving Intensive or Training Services in PY 2012



N = 525,239

Overall, the WIASRD data provides a portrait of a diverse service population. Participants enter the public workforce system with a wide range of experiences, educational backgrounds, and workforce competencies:

- Among all adults and dislocated workers in Program Year 2012, 12 percent were employed while they participated in WIA services; 7 percent were younger than 22, 22 percent were 22 to 29, 34 percent 30 to 44, 22 percent 45 to 54, and 16 percent 55 and older.
- Of adult and dislocated workers, 29 percent (525,239 individuals) received intensive or training services, which are more likely than core services to incorporate TBL. Within this group 10 percent had not obtained a high school degree or equivalent credential, and another 44 percent had a high school degree but no college education (See Exhibit 2). Further, those receiving intensive or training services may face additional barriers. For example, 3 percent had limited English proficiency.
- Finally, the limited amount of data on these participants' skills and experiences show a relatively small, but consistent proportion of participants with low basic skills and limited credentials. The

[7] These are characterized by the WIASRD as "exiters" and include those who had finished participation from January 1, 2011, to March 31, 2013, and those who started participation before July 1, 2013, but had not finished participation by March 31, 2013. Data presented are based on the authors' calculations.

relative proportions of these low skill and low credential populations appear fairly stable over the past five years (Social Policy Research Associates 2013).

TBL may be a useful strategy for meeting the needs of the diverse population served by the public workforce system given its capacity to adapt learning to meet the needs of individual learners. This may be particularly true for the more sophisticated models.

While varied skill levels represent one consideration in the adoption of TBL, other characteristics of WIA participants may influence the utility of TBL for this population. For example, 12 percent of WIA participants in intensive or training services in Program Year 2012 were single parents facing time constraints related to childrearing, which may make them more inclined towards TBL for the flexibility it affords over a traditional class.

Finally, recent national-level data points to the general level of TBL preparedness within the U.S. population as a whole. Using more nuanced and expanded definitions of literacy, numeracy, and problem solving in technology-rich environments, data from these surveys suggest that U.S. adults in general may face significant challenges to successful engagement in TBL. This theme is echoed in surveys of beliefs and skills assessments that go beyond the more basic signals of skills in the WIASRD data.

First, a survey of local Workforce Investment Boards (WIBs) in 2013 found that 63 percent of executive directors believed participants' levels of technological literacy represented a significant barrier to TBL within their AJCs (Gan et al. 2013). A survey from the Pew Research Center's Internet and American Life Project found that the 32 percent of adults who did not use the Internet cited such barriers to usability as they found it too difficult or frustrating, they lacked the skills or did not know how, or they were too old to learn (Zickhur 2013).

These perceptions of challenges to TBL engagement may be grounded in a realistic assessment of skills. As noted in the introduction, findings from the PIACC study found that a large proportion of U.S. have low levels of literacy and numeracy as well as difficulty in using technology.

Collectively these data suggest that, in addition to building occupational skills, the workforce system must have the capacity to build foundational skills for technology-rich environments. Many factors shape the role that TBL can play in meeting these challenges. The remainder of this section describes these factors and the results from empirical studies exploring the relationship between learner characteristics and TBL adoption, engagement and success. Overall, very little empirical evidence exists that rigorously establishes pre-conditions for successful engagement in TBL or the factors that moderate engagement. Rather, the literature tends to examine outputs and proximal outcomes, such as program retention, attrition, and completion. These measures serve as proxies for distal outcomes in that they reflect the extent to which individual learners have the psychological make-up, the level of preparedness and technological-readiness, and supports needed to sustain the demand for TBL and remain fully engaged.

3.1.2 Technological Access and Readiness

Among a host of other considerations, sustained demand for TBL may depend on learners' technological access and readiness, which is commonly referred to as the "digital divide" (see Chapter 2). Selwyn (2004) presents a useful framing of the relevant empirical literature, which separates components of the digital divide to argue that learners' experiences using technology are defined by their access to three types of resources. In this schema, economic capital represents material resources and the ability to purchase technology; cultural capital, the skills and familiarity with technology; and social capital, a network of contacts who are also familiar with technology.[8]

Data from the public workforce system suggests that the issue of access (economic capital) is pertinent for the adoption of TBL. In a survey of local WIB executive directors in 2013, Gan et al. (2013) found that one-third (33 percent) believed that participants' access to the required technology represented a significant barrier to TBL within their AJCs. These perceptions mirror issues of technology access and readiness across the broader U.S. population. As of 2010, 23 percent of US households did not have access to computers at home and 29 percent did not have Internet access at home (OECD 2013). The Pew Research Center's Internet and American Life Project found that, as of May 2013, 15 percent of U.S. adults did not use the Internet or e-mail (Zickuhr 2013). Within the Pew survey, 7 percent of those who didn't use the Internet cited a lack of access as the primary barrier, and another 6 percent reported that it was too expensive (Zickuhr 2013).

To understand the impacts of the digital divide, researchers have studied the relationship of successful completion of a course to different aspects of the individual's experience and personal characteristics. At present, the correlational evidence for the effect of the digital divide for workforce development is mixed: there appears to be no consistent evidence of the relationship between digital access, digital readiness or skills, and success in TBL (e.g., Lindsay 2005).

The literature on TBL course completion suggests that some measures of computer skills or previous experience in a technology-only course are not correlated with higher rates of TBL course completion (Muse Jr. 2003; Yukselturk 2010; Kemp 2002). Muse, Jr. (2003) considered the relationships between technology-only course completion and three forms of technological readiness: measures of basic computer skills (e.g., comfort with installing and running a CD), basic Web-based skills (e.g., ability to use a search engine or reference Web material in an academic paper), and confidence in using computers. Of these three, only Web-based skills were moderately and positively related to course completion; computer skills and confidence were not significantly related to course completion once other factors were taken into account. Moreover, Muse Jr. (2003) and Kemp (2002) both found that previous experience in, and even previous completion of a technology-only course, did not explain patterns in technology-only (i.e., online) course completion. At least one study of participation in technology-only learning environments reaches a similar conclusion. In an international study of a Turkish IT training course, Yukselturk (2010) did not identify significant differences in level of participation in discussion forums among learners with and without previous Web-based learning experience. Conversely, Harrell and Bower (2011) reported a significant relationship between basic computer skills and course completion, but in this case, higher skills were associated with a *decrease* in course completion. The authors suggest that this result could be due to measurement error, a statistical anomaly, or the potential scenario in which learners with very high computer skills fail to engage with course material, thinking it

[8] The nearest test of these three concepts jointly in a technology setting for workforce development is the Lindsay (2005) correlational study of unemployed adults at a public workforce system office in Glasgow, Scotland, and their job searches using technology-only. Using this data, Lindsay found that economic and cultural capital were significant predictors of an individual's use of the Internet to search for a job. Individuals with higher income levels, more education, and positive self-perceptions of their computer skills were more likely to use the Internet. Further, Internet use was lower among individuals with greater than one year of unemployment. Approximations of Selwyn's social capital concept—the use of a social network for job search and whether an individual lived alone—were not significant predictors of technology use.

is too simple, and subsequently perform poorly. While measures of specific computer-related skills, attitudes, and experiences have only weak relationships with TBL success in the current literature, these measures are still being developed and validated.

In contrast, the evidence for more established measures of skills is stronger. The literature has identified more general readiness for learning as a significant factor in predicting success in TBL courses. Academic aptitude, as typically measured by grade point average (GPA) before enrollment, has been consistently found to positively predict TBL course completion. Muse Jr. (2003), Harrell and Bower (2011), and Aragon and Johnson (2008) all found that community college learners with higher GPAs are more likely to complete a technology-only course. In general, controlling for GPA, other academic characteristics (e.g., education level and scores on remedial writing and math tests) have not been found to significantly correlate with course completion (Aragon and Johnson 2008; Park and Choi 2009; Muse Jr. 2003). Moreover, Aragon and Johnson (2008) did not find significant differences between completers and non-completers in terms of their readiness for self-directed learning, which is a concept with many definitions that generally applies to learners who have primary responsibility for planning, carrying out, and evaluating their own learning experiences (Ellinger 2004). Finally, a 2008 review from the National Institute for Literacy reports that there is no threshold level of literacy or language proficiency that adult learners need to have obtained in order to use the Internet for independent learning (Silver-Pacuilla 2008). This was true even for adults with lower levels of literacy and language proficiency, who were found to be able to engage with technology-only learning.

3.1.3 Psychological Factors

There is limited empirical literature focused on psychological mediators to engagement in TBL for workforce development. However, the literature does describe a number of psychological characteristics that may independently affect both participation in TBL and the level of engagement in or success with it. In particular, three categories of psychological mediators have been studied in relation to TBL engagement and course completion:

- Motivation or resilience;
- Perceived locus of control; and
- Social presence.

Survey and correlational data suggest that each of these psychological factors may play a role in TBL engagement, but the evidence is not strong.

Some literature has hypothesized that learners' levels of motivation or resilience may explain the likelihood for TBL course completion (Kemp 2002; Park and Choi 2009). The empirical literature provides some insight into this mediator of TBL engagement, but the evidence is mixed, and findings may be partially attributable to self-selection into TBL courses. On one hand, in descriptive surveys about the relationship between motivation and TBL engagement, Stanford-Bowers (2008) found that faculty and administrators tended to identify "self-discipline" and "self-motivation" as relatively important factors leading to persistence in technology-only community college classes, while learners were likely to cite "independent learning or responsibility" as a factor. Likewise, Kemp (2002) found that TBL course completers scored higher on a number of measures of resilience, including an ability to generate constructive activities, develop healthy relationships, and have the confidence to make the most of bad situations. For instance, Park and Choi (2009) found that a course's relevance—the extent to which a learner perceives a course as relevant to their interests—is significantly associated with higher rates of TBL course completion. Conversely, other studies report less evidence for the effects of motivation, when controlling for other moderators. For instance, Muse, Jr. (2003) found that while motivation is positively associated with completion, the relationship is weak when considered in conjunction with other factors, such as GPA. Other literature has hypothesized that learners' locus of control may impact their success in a TBL course (e.g., Harrell and Bower 2011). That is, measures of the extent to which individuals perceive events to be contingent upon either their own behavior (an internal locus) or the result of uncontrollable factors (an external locus) may affect TBL persistence and success. However, more rigorous analyses, which include multiple explanatory variables, tend to find no significant explanatory power from measures of locus of control on these outcomes (Muse Jr. 2003; Harrell and Bower 2011).

Although not researched as extensively, another psychological dimension addressed in the literature is social presence. Learners' social presence includes their perceptions of technology-only classes as a social environment, their communication styles while engaged in technology, the extent of their interactivity mediated by technology, and their perceptions of the technology-only (i.e., Internet) environment as sufficiently safe, reliable, and private. (Liu, Gomez, and Yen 2009) found that the amount of social presence significantly predicted TBL course retention among a sample of community college learners.

3.1.4 Support for Engagement in TBL

Finally, it is important to emphasize that an individual's success with TBL may be moderated by an effective support structure that, in turn, allows for sustained engagement in TBL. The presence of these support structures is especially important in technology-only environments, given evidence that post-secondary learners are more likely to enroll in TBL (i.e., distance education) courses if they have dependents, are married, are employed full-time, or have a mobility disability (Radford 2011).[9] This key consideration bridges both learners and providers, since either may influence the context in which a learner engages in TBL. In particular, the literature has examined moderators related to support (or lack thereof) for learners' engagement in TBL These include both environmental factors and the structure of the course itself. Evidence suggests that the following external factors are related to TBL success:

- Employers' supports for engaging in training;
- Flexibility in balancing personal or time constraints; and
- Supports for interacting with course technology.

An analysis of adult learners age 30–45 by Kemp (2002) focused on the role that significant life events, external commitments, and an individual's psychological resiliency play in their likelihood to persist in technology-only education. Kemp found that, in general, external factors such as familial, financial, and community-based commitments did not significantly predict dropout, but external work commitments were negatively associated with persistence. Similar patterns have been found elsewhere. In Park and Choi's analysis, the authors included measures of family support (the extent to which a learner's family was supportive and understanding of his/her time constraints) and organizational support (the extent to which learners' employers flexibly accommodate training and supervisors show interest in learning).

9 This data applies to all post-secondary learners, including those in four-year institutions of higher education. Data for the population most relevant to the workforce system (e.g., those in two-year colleges) were not available.

They found that only organizational support, not family support, significantly predicted course completion (Park and Choi 2009).

The important role of external supports has also been identified in other studies. In 2001, DOL awarded a $500,000 grant to the New Jersey Department of Labor to finance a pilot program that provided poor single mothers with a computer and printer with which to participate in an asynchronous, technology-only training program focused on IT skills. The course lasted one year, and learners were permitted to keep the computer upon completion. Participants cited numerous obstacles to successful completion of the program, particularly time management, technical or computational limitations, and a lack of both technical support and interpersonal support (Gatta 2005). Similarly, in interviews with learners who dropped out of a technology-only course, researchers have identified technology limitations, such as difficulties with course software, as a common reason for not completing a course (Aragon and Johnson 2008; Muse Jr. 2003). Aragon and Johnson's sample of rural community college students identified "personal/time constraints" or "course design and communication" as the two most common self-reported reasons for dropping out.

Overall, the empirical evidence for learner considerations in adopting TBL is mixed. Within the public workforce system, and the United States in general, technology access and literacy may represent a major barrier to successful engagement in TBL. In particular, support for basic and learning skills and for interactions with technology appears to be important learner considerations for many TBL programs.

3.2 Provider Considerations

In making decisions about the focus and pace of TBL adoption, training and workforce-related program providers must also give weight to a variety of considerations in addition to those discussed above. These additional factors can be categorized according to the steps or actors associated with each stage of providing TBL as a system, which are:

- Development,
- Procurement, and
- Implementation.

While, ideally, these three steps work in concert to provide TBL to the learner and they may naturally overlap (i.e., for new products, the developer is often the implementer and there is no procurement), or they may represent distinct perspectives on TBL design and usage. Additionally, providers must take into account the perspectives of key stakeholders, like employers, in deciding whether and how to adopt TBL.

3.2.1 Developer Considerations

Developers may "create" TBL products by adapting traditional curricula, by creating new TBL-specific products, or by combining the two approaches. Developers may have two goals in mind: creating a high-quality product and creating a credible product. In terms of quality, ideally, TBL development takes into account the learner considerations described above, as well as pedagogical and learning theory. Beyond quality, however, developers also take into account ways of communicating about that quality.

Development of new TBL can be costly. It may parallel, in part, the development of any new curriculum or learning practice. Development may begin from fundamentals with basic research, adult learning theory, or adapt existing materials. For public workforce system representatives, one survey found that the most noteworthy perceived barriers to TBL implementation were cost related. A majority of local WIB representatives and over one-third of state workforce representatives reported that the upfront costs associated with course development and the implementation of new technologies were major barriers to TBL adoption (Gan et al. 2013). Given the amount of development undertaken by career and technical education (CTE) providers, it is likely that they also face significant development costs. For the 2006–2007 academic year, nearly every public two-year college that offered for-credit technology-only education courses developed and paid for the development of those courses (Parsad and Lewis 2008). Finally, development costs are a significant consideration at institutions of higher education more generally. In 2000–2001, program development cost—generally a fixed up-front cost—was the top barrier to starting or expanding technology-only education as identified across all institutions of higher education (Tabs 2003).

In addition to the direct costs of developing TBL, developers may also face indirect costs, such as costs associated with disseminating their products and signaling their quality and utility. While some developers and their products may have credibility by dint of association or reputation, they or others may also use credentials as a way to communicate the quality and worth of their TBL learners' experiences and accomplishments. Credentials, such as digital badges, may communicate the credibility of a TBL program by signaling verifiable skills, interests, and achievements through specific projects, programs, courses, or other activities (e.g., Alliance for Excellent Education and Mozilla Foundation 2013).

3.2.2 Procurement Considerations

In some instances, training and workforce-related program providers may choose to procure and implement already-developed TBL materials (e.g., GED or other high school equivalency curricula and materials) or contract for implemented TBL programs (e.g., through an individual training account). For example, in the 2006–2007 academic year, nearly half of public two-year colleges that offered for-credit technology-only education courses acquired those courses from a commercial vendor and nearly one-fifth procured them from another post-secondary institution (Parsad and Lewis 2008). Given the variety of commercial and publically-accessible TBL resources available, the considerations of providers in procuring TBL are also important.

First, procurement may require assessing both the "fit" of materials for a particular context and the quality of the materials. One way implementers may determine fit for their workforce system may be by assessing the needs of their local labor markets. Looking systematically at the local labor market factors that determine how community colleges choose to target their technology-only education programs, Githens et al. (2012) found that institutional characteristics and local economic and social factors generally are not related to the volume of technology-only program offerings associated with high-growth and high-demand occupations. Recognizing some limitations in data availability, this analysis included factors such as the local unemployment rate, demographic distributions in college enrollment, and the education level of the local area. There was some evidence that technology-only programs targeting high-growth occupations were more common among colleges with more part-time learners and those subject to more state-level, centralized control, but these were of minimal practical significance.

Further, Githens et al. (2012) reports that community colleges sometimes appeared to show little responsiveness to states' workforce development needs, identified as projected labor market demands and the trajectory of growing occupations. This is true within the TBL offerings as well. About 26 percent of colleges that offer technology-only occupational programs do so in what the authors consider the five fastest-growing (high-growth) occupations, and about 39 percent offered such programs in what the authors consider to be top-10 occupations with the most projected openings (high-demand). Moreover, less than 10 percent of all technology-only occupational programs were associated with a state's high-growth or high-demand occupations. These findings stand in contrast to those that document that about two-thirds of public, two-year institutions report giving moderate or major consideration to the needs of employers when making decisions regarding technology-only education offerings in 2006–2007 (Parsad and Lewis 2008).

Another way implementers may assess the fit of TBL is to consider their institutional context. Some, albeit dated, evidence suggests that providers must view TBL as aligned with their institution's mission. In a survey of post-secondary institutions, the lack of mission alignment was the top barrier to starting or expanding TBL offerings among schools that reported no plans to start a technology-only education program in 2000–2001 (Tabs 2003).[10] Conversely, among public, two-year institutions that already offered these types of courses in 2006–2007, technology-only education was viewed as an opportunity to expand the access and availability of a college education (Parsad and Lewis 2008).

A final procurement consideration is the ability to assess the value of various TBL offerings, in terms of both quality and credibility. In the survey of local WIB representatives, 45 percent of executive directors cited assessing the quality of TBL as a significant barrier to local adoption (Gan et al. 2013). Beyond the quality of the content, concerns remain about the credibility of any educational program —delivered through TBL or not. Whereas traditional educational institutions may be credentialed by a governing body, individual TBL programs or resources are unlikely to be. In such cases, those seeking to procure TBL may use other signals of credibility, such as association of the program with a credible developer or institution, widespread use of the program or word of mouth, or the value of the credential associated with program completion.

One common means of conferring credibility is through demand. In particular, for TBL to be a successful strategy for the workforce development system, employers must accept TBL as a viable tool through which workers and learners can learn the skills necessary for employment. We discuss employer considerations further below.

3.2.3 Implementer Considerations

Implementation considerations are a final set of factors to be accounted for by training and workforce-related program providers in adopting TBL. These factors may relate to capacity or instructor skills as well as to their willingness to implement TBL. Though implementers may not pay directly for the costs associated with course development or procurement, they may face additional considerations in implementing TBL and supporting learners and instructors. In particular, according to a survey of its member institutions, the Instructional Technology Council (Mullins 2013) reported that obtaining the necessary support staff to provide training and technical assistance, adequately assessing technology-only education classes, and providing services to technology-only learners are consistently among the top challenges faced by program administrators. In a study of the Web-based Workplace Essential Skills (WES) educational system developed by the Literacy Link project, researchers identified issues related to teacher preparedness, adequacy of technical support systems, the availability of sufficient technology, and careful curricular planning as important elements that determine the effectiveness of the Web as an

[10] The survey did not ask the follow-up question about the institutional missions or how technology-only offerings aligned, or failed to align, with those missions.

instructional tool (Askov et al. 2003). While this study is more than 15 years old and the technologies used in TBL have evolved in the intervening period, the issues in TBL adoption discussed, such as preparedness and technical assistance systems, likely remain. Moreover, the authors offer a number of lessons for implementation that remain useful, including a willingness to experiment and potentially fail with initial strategies, the importance of program orientations for new learners, and a need for approaches to teaching asynchronously that differ from classroom teaching methods (Askov et al. 2003).

Finally, the adoption of TBL for workforce-related training and education also hinges on instructors' willingness and ability to incorporate technology into their current instruction. For example, in community colleges, administrators report that they must appeal to faculty members that need more support to incorporate TBL and that are more skeptical of TBL's advantages (Cox 2005). Adopting TBL does appear to increase as instructors' become less anxious about technology and as the perceived barriers to integrating TBL decrease (Kotrlik and Redmann 2009; Jones 2011). However, other data suggest that CTE instructors report only mild or modest technological anxiety and perceive only a few minor barriers to incorporating TBL into their classroom (Jones 2011; Kotrlik and Redmann 2009). Further, Kotrlik and Redmann's (2009) sample of CTE teachers consistently reported that they have not only made physical changes to accommodate technology in their classrooms, but they have also assigned computer-related activities on a regular basis, with the belief that technology has become a standard tool for their learners.

CTE instructors report that of all the modest barriers to the integration of technology into instruction, course development appears to be the most commonly cited (Kotrlik and Redmann 2009). Specifically, some CTE instructors feel they do not have enough time to develop lessons that use TBL or cannot make time in their curricula for TBL lessons. Likewise, adult education literacy instructors have reported similar time constraints, identifying their most serious barriers to teaching with technology as issues with a higher priority and a lack of paid time to develop a comfort with using technology (Carter and Titzel 2003). Finally, inadequate access to technology also was commonly identified as a serious barrier. For example, Kotrlik and Redmann (2009) found that instructors in business and marketing programs reported lower barriers to adoption and were more likely to have integrated technology into their instruction than CTE instructors in other programs, like health occupations education, agriscience education, and technology education.

Additionally, it appears that some CTE instructors have yet to take the next step toward what some researchers consider "advanced integration" (Jones 2011). These steps could entail innovative uses of technology allowing learners to design their own learning activities and collaborate with individuals across disciplines or the regular use of technology-based games or simulations (Kotrlik and Redmann 2009). Thus, it may come as no surprise that of all the mild sources of technological anxiety, Kotrlik and Redmann's (2009) sample reported that the most serious source was a feeling of not being able to keep up with important advances, implying that cutting-edge technologies may be the most anxiety-inducing. Given that the majority of instructors report that they learn about the process of integrating technology into the classroom through attending conferences or workshops, this may be the appropriate avenue through which to address any existing anxieties (Kotrlik and Redmann 2009; Jones 2011).

3.2.4 Employer Considerations

Employers are the primary provider of workforce training within the United States. In 2013, employers in the United States are estimated to have spent over $450 billion on training, primarily for their employees

(Carnevale, Jayasundera, and Hanson 2012 as cited in The White House 2014a). [11] Businesses' investments in TBL may combine a number of the provider considerations discussed above, because employers may simultaneously serve as the developer, procurer, and implementer of TBL.

Further, employers, in their role of key stakeholders in workforce training and education may shape the use of TBL within the public system. That is, the potential for expanded adoption of TBL programs depends not only on its effectiveness as an instructional tool, but also on its full acceptance among key stakeholders. For TBL to be a successful strategy for the workforce development system, employers must accept TBL as a viable tool through which workers and learners can learn the skills necessary for employment. However, the limited data available suggests that employer buy-in remains a challenge.

Adams and DeFleur (2006) found that hiring managers often express a substantial preference for a candidate with a traditional degree over a candidate with a degree from a technology-only or blended institution. However, they do not disentangle whether this is related to TBL, a particular type of TBL, the rigor of the degrees, or characteristics of the provider institutions. Additionally, the authors replicated this finding among managers specifically seeking employees for healthcare occupations (Adams, DeFleur, and Heald 2007). Moreover, a majority of those hiring managers reported that the mix of technology-only versus traditional courses taken by an applicant would be important to hiring decisions. This further supports the evidence that employers may have a preference for graduates of traditional training programs over online programs. However, Adams and DeFleur's findings may not generalize to the workforce investment system since the hiring managers surveyed for the study were often searching for college-educated applicants with four-year degrees for management positions.

Within the workforce system broadly, general employer acceptance of TBL is less of a concern. A recent survey of state and local representatives of the public workforce system showed that the majority do not consider employer acceptance of TBL to be a significant barrier to its implementation, and by association, its credibility (Gan et al. 2013).

3.3 Summary

The literature profiles an array of considerations that shape individual and institutional decisions to adopt and pursue TBL opportunities. On the learner side, some recent data suggest that the biggest challenge is a low level of technological literacy, which is widespread among the US adult population (OECD 2013). This will have an impact on the demand for TBL by moderating awareness, interest, and uptake. The much-discussed "digital divide" remains a barrier to access for a portion of the population, but that may be diminishing as mobile devices become more universal and join laptop and desktop computers as a core delivery platform for TBL. That said, to date, the literature has not conclusively demonstrated the relationship between technological literacy or readiness for self-directed learning and TBL completion or success. While the digital divide may keep individuals from accessing TBL, it may not hinder their success once they are engaged with TBL. Further, psychological factors appear to be more important for driving success in TBL, most notably how much of a social presence the TBL opportunity provides.

From an institutional perspective, the literature focuses more on the barriers to TBL creation, adoption and use, than on the factors driving it. First, the cost of development (either from scratch or repurposing

[11] By way of comparison, the federal budget for employment and training programs was approximately $17 billion in fiscal year 2014 (The White House 2014a).

existing materials) is the most widely cited factor affecting institutional providers' decisions to make TBL opportunities available. In procuring or adopting already-established TBL, some providers appear to be concerned about TBL quality, as well as mirroring the degree of skepticism about TBL that is expressed by employers. Additionally, time is a commonly cited barrier to TBL implementation: in particular, the time instructors need to gain familiarity and comfort with emerging technologies as well as customize TBL materials for their particular learners and context.

Finally, the literature identifies some gaps between supply and demand, such that providers' investments in TBL tend not to mirror their broader training investments in high-growth, high-demand occupations. These challenges suggest that future investments in TBL must account for the confluence of these factors and that research can help to disentangle their effects.

4. Current TBL Use in Workforce Services, Training, and Education

Myriad programs and investments across the public and private sector contribute to workforce training and education in the United States. This chapter focuses on the public sector and discusses the programs funded at Federal level by DOL and the U.S. Department of Education (ED). The primary DOL programs (providing services and training to unemployed and underemployed adults, dislocated workers, and youth) are under WIOA Titles I and III, and the Trade Adjustment Assistance Act.

The primary federal investment in occupational education however is funded through Federal student aid programs, especially Pell Grants under ED. Additional ED support goes toward providing funds for states for secondary and post-secondary occupational education through the Carl D. Perkins Career and Technical Education Improvement Act of 2006. Federal resources also support foundational literacy and numeracy skills, including adult education and family literacy programs authorized under Title II of WIOA and under Pell-funded college remediation, also known as developmental education. Overall, these skill-building activities provide many opportunities for using technology-based approaches to support learning.

These programs and their use of TBL are briefly described below. The chapter begins with the existing network of employment training and educational services, primarily emphasizing the public workforce system, and the use of TBL in programs authorized under WIOA. The chapter concludes by considering the use of TBL in CTE, adult education, and developmental education.

4.1 Workforce System Program and Services

The public workforce system consists of state and local agencies that are responsible for delivering employment-related services to individuals entering the workforce for the first time as well as individuals who are unemployed, underemployed, dislocated, or who want to change jobs. Concomitantly, these services are designed to align with the hiring and skill development needs of local employers and the evolving requirements of the local labor market and regional economy more broadly. Authorized under WIOA, the system operates principally through the roughly 3,000 American Job Centers, (AJCs). One hallmark of the system described in the legislation is the significant degree of state and local self-determination in the administration of programs, though partnership with other local programs and services is required. Key programs under WIOA are those for a) adults and dislocated workers and b) youth.[12] Two major types of services are available to adults and dislocated workers access through local AJCs:

Career services, which include assessments of customers' aptitudes, skill levels, and interests; information on job openings, labor market trends, and training or educational options (typically provided via Internet-based assistance, case management, workshops, and job clubs. These services may also include prevocational services, such as basic workplace, computer, or literacy training, as well as supportive services and needs-based payments, and coordination of services and benefits from other programs (such as adult basic education or applications for Pell Grants); and.

[12] Through the Youth programs, which are less central to this review, youth have access to educational, mentorship, employment, and other available services.

Training services, which are provided in classroom or on-the-job for a specific occupation or set of occupations. AJCs can use Individual Training Accounts (ITAs) to pay for the training from eligible providers or contract with providers for group-based training. Providers typically include community colleges, CTE schools (including proprietary schools), as well as union-based training programs and sometimes four-year colleges or universities (particularly for certain health occupations). Many of these programs receive indirect support from the Perkins Act and from Pell Grants, both administered by ED.

Other ETA program for adults include: Trade Adjustment Assistance (TAA), Senior Community Service Employment Program (SCSEP), which are separately authorized and administered. Other youth programs include: Job Corps which provides disadvantaged youth with academic instruction, job training, and community service in a residential setting and YouthBuild, which provides low-income youth ages 16 to 24 the opportunity to learn job skills by building affordable housing while simultaneously working toward their high school equivalency or high school diploma. Two other programs offer employment and training services targeted specifically to Native Americans and migrant and seasonal farmworkers and their families.

4.1.1 ETA Support for TBL

ETA has long been involved in the development of electronic tools to jobseekers, employers, and those responsible for administering its programs. ETA offers an entire suite of E-tools, and online resources are accessible through the CareerOneStop Web site (DOL 2012) to provide information on careers, training options, job listings, as well as linked tutorials on how to conduct a job search, market oneself to employers, and develop basic skills and attitudes required to keep a job. ETA also offers online training and information for state and local administrators about system-wide initiatives (DOL 2008b, 2011).

ETA has also promoted utilization of technology via specific research and policy initiatives. Under the TBL Initiative, which began in 2006, ETA issued Training and Employment Guidance Letter (TEGL) No. 17.07, *Using Technology-Based Learning in the Workforce Investment System*, on January 3, 2008. Following that issuance, ETA convened experts to discuss 21st century applications of learning technologies to address workforce training needs, shared best practices in webinars and regional forums, and supported a 2006 research report summarizing current trends in TBL and its effective uses (Koller, Harvey, and Magnotta 2006).

The TBL Initiative also involved the issuance and evaluation of a series of **Technology-Based Learning Grants** (Dunham, Estrella, and Nyborg 2010; Dunham et al. 2011; Maxwell et al. 2013). After some initial success with its first demonstrations under the Initiative, ETA awarded an additional $10 million to 20 grantees to support models of TBL that would stimulate innovative uses of technology for training that had the potential to be scaled up for wider use.

4.1.2 The Use of TBL Within Public Workforce Programs

A 2011 evaluation of the TBL grantees stands as the most in-depth assessment of how TBL has been used specifically among DOL-funded programs (Dunham et al. 2011). Evaluators found that TBL programs varied in their design and delivery along a number of dimensions, including duration; award of certificates, degrees, and licenses; and targeted populations, such as incumbent workers, dislocated workers, and unemployed individuals. Key learning from the evaluation included the need for communication and interaction among peers and with instructors, through such means as in-person sessions and a social networking platform.

Other major research (Gan et al. 2013) on use of TBL found that 40 to 50 percent of local programs offered blended learning programs to build computer software, computer, job application, or soft skills, and another 10 to 20 percent reported using technology-only approaches to teach these skills in their AJCs.

State and local workforce programs also use electronic resources developed by the private sector. For example, a number of states have licensed ACT's WorkKeys assessments to measure foundational and soft skills and to help job seekers obtain certifications that can be presented to potential employers, and some states' workforce systems offer training for ACT's National Career Readiness Certificate, which combines training for three assessments, Applied Mathematics, Locating Information, and Reading for Information. A number of states also use Career Ready 101, which uses TBL strategies such as interactive exercises offered online or through flipped-classroom strategies.

Beyond the use of TBL for career services and general job-readiness, the public workforce system also invests in TBL for occupational skills building. This is done primarily through contracting with external training providers, like the career and technical education providers discussed in the following section. However, little research has systematically investigated the use of TBL among the workforce system's training providers. In a survey of Executive Directors of Local Workforce Investment Boards, Gan et al. (2013) found that 25 percent of the largest training programs that had ITA contracts utilized TBL for occupational training. A 2006 qualitative evaluation of the Job Corps program found that four of six selected Job Corps centers were using e-learning programs to deliver literacy services, including Read180 and KeyTrain (KPMG 2006).

Finally, as noted in the introduction to this report, the Skills Commons houses free and open-licensed learning resources, including those developed as part of DOL's TAACCCT grants. The TAACCCT grants, awarded in four rounds of approximately $400-$500 million, were encouraged or explicitly required by ETA to incorporate TBL into skills training, i.e., "to develop online training programs that build on current advances in science and technology and are scalable to large numbers of [Trade Adjustment Assistance] eligible workers and other adults" (DOL 2013a, 6). Further, as a condition of funding, grantees were required to incorporate some features of TBL into their occupational programs.

4.2 Career and Technical, Adult, and Developmental Education

As noted above, the other Federal investments in workforce developmental and education are made through student aid programs, especially Pell Grants, which assist nearly 9 million undergraduates, of which more than half of whom (5.1 million) enroll in in two-year public or proprietary institutions. Other major investments include funds for secondary and post-secondary career and technical education (CTE) through the Perkins Act and support for adult education and family literacy under WIOA Title II. We review each of these programs—CTE, adult education, and developmental education— below, followed by a summary of Federal initiatives and guidance that shape the use of TBL. This section concludes with a discussion of the current prevalence and use of TBL.

4.2.1 Career and Technical Education

Federal support for CTE is longstanding, beginning with the First Morrill Act of 1862, and authorized today under the Perkins Act, which provides approximately one third of the funding for CTE and is one of the largest sources of Federal institutional support for community colleges. The current law attempts to ensure that academic and technical content are rigorous and linked across secondary and post-secondary levels; that equipment is up-to-date with industry practice; that teachers and counselors are prepared to meet evolving academic and technical standards; and that offerings are aligned with the needs of employers, industry, and labor (National Alliance for Partnerships in Equity 2014).

Based on the reforms accompanying the Perkins Act, CTE tends to be organized into 16 broad career clusters such as health sciences or manufacturing. Programs of study are structured around career pathways that provide a sequence of training steps that lead to progressively more advanced credentials within a given career or occupational track. For example, in the Perkins health science career cluster, there are five different career pathways from therapeutic services to biotechnology research and development.

Post-secondary occupational programs, broadly speaking, are offered through a variety of institutions and venues including high schools; area CTE centers; community colleges; public and private four-year universities; vocational and technical colleges; employers through apprenticeships and on-the-job training; adult education centers; regional training centers; and detention centers and correctional facilities (Dortch 2014). Many of these institutions and venues are eligible to receive Federal student aid funding and some of them—e.g., community and technical colleges, area CTE centers—receive support from the Perkins Act.

Most adults and dislocated workers in the public workforce system engage with CTE through sub-baccalaureate post-secondary programs offered by public and private for-profit institutions of higher education. These programs may include formal programs resulting in associate degrees and certificates; they may also award industry-recognized credentials and prepare students to qualify for professional licenses. These certificate and degree programs tend to be eligible for Federal student aid.[13]

4.2.2 Adult Education

The Adult Education and Family Literacy Act (AEFLA, WIOA Title II),[14] is the primary Federal legislation that supports adult education (AE) below the post-secondary level. Services under AEFLA are organized into three levels: Adult Secondary Education (ASE) for learners with literacy skills between 9th and 12th grade equivalence, Adult Basic Education (ABE) for learners with literacy skills below 9th grade equivalence, and English as a Second Language (ESL) (U.S. Department of Education 2013b). In program year 2012-2013, approximately 1.71 million individuals participated in AEFLA-funded adult education activities. Almost half of adult education students participated in ABE (48 percent), 12 percent in ASE, and the remaining 40 percent in ESL.[15] The need for a minimum level of technological literacy within ASE is particularly acute for individuals seeking a secondary credential since, as of 2014, the General Educational Development (GED®) tests are computer-administered assessments. Other high

---

[13] To apply for Federal student aid, both the programs and the learners themselves have to meet separate eligibility requirements (see, for instance, http://www.clasp.org/admin/site/documents/files/Pell-Grants.pdf)

[14] WIOA, 2014, Title II, Adult Education and Literacy Act reauthorized the Workforce Investment Act of 1998, Title II, Adult Education and Family Literacy Act (AEFLA), which replaced the National Literacy Act of 1991 and the Adult Education Act of 1996.

[15] Data are from the U.S. Department of Education, Office of Career, Technical, and Adult Education, 2012-2013 National Reporting System Aggregate Tables, Table 4 (https://wdcrobcolp01.ed.gov/CFAPPS/OVAE/NRS/reports/index.cfm)

school equivalency tests - the Test Assessing Secondary Completion (TASC) and High School Equivalency Test (HiSET) - are available in both computer-based and paper-based formats.

AEFLA-supported services are delivered by local education agencies (LEAs), community colleges, community-based organizations, libraries, correctional institutions, and volunteer literacy organizations (U.S. Department of Education, 2013b). AEFLA's funding primarily flows from the Department of Education to state agencies, which in turn award sub-grants to local service providers, the majority of which are LEAs (but include other educational and community-based organizations).

4.2.3 Developmental Education

Developmental education, remedial instruction at the pre-college level in reading, writing, math, and the English language for learners who are assessed as not qualified for post-secondary-level classes is offered only to students enrolled in post-secondary institutions. The structure of developmental education programs is typically similar to that of traditional college courses, i.e., offered in a sequence of courses (e.g., Reading or Math 030, 060, 090) in the college setting, and regular tuition is charged for the courses. Most often, developmental education courses do not carry credit toward a degree (Foster, Strawn, and Duke-Benfield 2011).

Community colleges are the primary providers of developmental education. Recent Federal data indicate that 68 percent of community college students and 40 percent of students at open-access four-year colleges take at least one remedial course (U.S. Government Accountability Office 2013). While developmental education is a category of coursework and not a specific Federal program, Federal student aid, in the form of Pell Grants, often support students pursuing programs of study that are otherwise eligible for such support. In the 2007-2008 academic year, 36 percent of community college students enrolled in developmental education also received Federal student aid (Foster, Strawn, and Duke-Benfield 2011).

4.2.4 ED's TBL Initiatives and Guidance

The Education Department has looked to technology as a means to enhance the quality and effectiveness education in both the K-12 and postsecondary levels, including for occupational preparation and adult education. It has developed a number of planning documents, such as the National Education Technology Plan (NETP), which lays out a vision of how technology can improve teaching and learning (U.S. Department of Education 2010). The plan, entitled "Transforming American Education: Learning Powered by Technology," sets the standard for integrating technology into education, and establishing long-range goals and recommendations for action at the Federal, state, and local level to be achieved by 2015. The major goals of ED's NETP are the following:

- **Learning**: Change the learning process so it's more engaging and tailored to students' needs and interests.
- **Assessment**: Measure student progress on the full range of college- and career-ready standards and use real-time data for continuous improvement.
- **Teaching**: Connect teachers to the tools, resources, experts, and peers they need to be highly effective and supported.
- **Infrastructure**: Provide broadband connectivity for all students, everywhere—in schools, throughout communities and in students' homes.

- **Productivity**: Use technology to help schools become more productive and accelerate student achievement while managing costs.

While the NETP applies to education broadly, the plan cites the adult workforce population as an underserved population that can benefit from TBL (U.S. Department of Education 2010; Russell, Lippincott, and Getman, 2013).

In 2012, OCTAE issued "Investing in America's Future: A Blueprint for Transforming Career and Technical Education." The white paper makes an explicit call for using advanced technology to address issues of access, quality, and rigor. Specifically the report noted that:

> New and emerging technologies are viable ways to solve problems of limited access, and uneven quality and rigor of academic and technical curricula. The proposal encourages the use of technology-enabled learning solutions that are accessible to, and usable by, students with disabilities and English learners, to create access to high-quality learning opportunities, including to technical courses and virtual work experiences. By promoting the use of technology, the proposal would connect those students who are served by consortia but who are disconnected due to geography to post-secondary institutions as well as to business and industry, even if those partners are not in close proximity. And students who are disconnected due to socio-economic status, disability, or language barriers would be connected as well (OCTAE 2012).

Similarly, in July 2012, ED established a new National Center for Innovation in Career and Technical Education (NCICTE) to assess the ways in which high-quality CTE programs can contribute to secondary and post-secondary instruction. One of four research areas that NCICTE prioritizes is technology-enabled learning, specifically assessing the prevalence and impact of technology-enabled learning on CTE (http://ctecenter.ed.gov/).[16] This research will help guide the development and improvement of CTE programs around the country.

A significant initiative by ED towards developing TBL is its awarding of the Center for the Analysis of Postsecondary Readiness in 2014 to focus on "innovative approaches to remedial assessment, placement, and instruction" in developmental education (Community College Research Center 2014). One major project of the center is to pilot and test the effectiveness of a technology-based assessment and placement system for placing students into remedial education. The assessment relies on insights from data analytics to process more data, including high school records, than is used for traditional placements. Another project tests an "Emporium" model of developmental math instruction in which the curriculum is modularized and put online for learners to access as needed (ibid). Both the Center and the policy initiatives detailed below have identified technology as a potential means to increasing both access to and quality of education and training for adults (U.S. Department of Education 2012; U.S. Government Accountability Office 2013).

In another effort to create additional funding for high-impact learning technologies in education at all levels, ED further proposed to invest $90 million to create an Advanced Research Projects Agency-Education (ARPA-ED), whose goal will be to "advance the state of the art and increase demand" for successful and potentially transformative technologies (U.S. Department of Education 2011). ARPA-ED will fund projects based on their potential to create a dramatic breakthrough in learning and teaching

---

16 http://cte.ed.gov/perkinsimplementation/ncicte.cfm

through technology. One recent ARPA-ED project is the Digital Tutor, developed for the Department of Defense's Education Dominance program.[17] Piloted with the Office of Naval Research, the Education Dominance program was intended to demonstrate that education could be improved by an order of magnitude and that this impact could be scaled up using technology. An "intelligent" tutoring model, called the Digital Tutor, was the technology and method of choice. The Digital Tutor was also piloted by the U.S. Department of Veterans' Affairs (VA). It helped unemployed veterans, who used the digital tutor for six months, to obtain IT jobs that pay $40,000 to $80,000. ED has funded the programming and testing of an Intelligent Tutoring System through the Center for the Study of Adult Literacy at the University of Georgia (Center for the Study of Adult Literacy). Through the center, AutoTutor will be expanded to include content related to adult education.

Similarly, the Office of Science and Technology Policy (OSTP) submitted a Request for Information (RFI) soliciting public comments on the design and implementation of ''pull mechanisms." Pull mechanisms, such as "pay for success bonds," may be strong incentives because they connect pay to research outcomes (push mechanisms, on the other hand, pay for research inputs). Specifically, OSTP seeks input on how pull mechanisms might be used to accelerate the development, rigorous evaluation, and widespread adoption of high-impact learning technologies (Kalil and Dorgelo 2014). These proposed initiatives and programs will complement and build upon the innovative work currently underway in the public and private sectors.

Finally, with the increasing prevalence of high-speed internet services and mobile phones, Open Educational Resources (OERs) have become more widely available, and several national initiatives are under way to raise awareness and support for OERs. These include the SkillsCommons, an open online library of TBL courses and tools developed through the TAACCCT grant program (https://www.skillscommons.org/). In addition, the Digital Literacy portal (DigitalLiteracy.gov) serves as a valuable resource to practitioners who are delivering digital literacy training and services in their communities. The Digital Literacy site links to a variety of free resources that not only address digital literacy, but also other workforce-related needs such as basic skills and job search, application, and preparation processes.

4.2.5 Prevalence and Use of TBL in CTE and Developmental Education

The use of TBL in CTE has been documented by Githens et al.'s (2012) work, which provides a characterization of TBL usage, with a focus on characterizing technology-only programs (rather than characterizing the prevalence of any TBL). In this work, individual technology-only (i.e., online) programs were categorized into broad groups of Career Clusters, such as Information Technology (IT), and then into subcategories of Career Pathways, such as Web and Digital Communications. Out of the total 1,201 technology-only programs, 41.2 percent were categorized into the Business, Management, and Administration Career Cluster, the most of any cluster. The second and third most common clusters were Information Technology (14.8 percent) and Health Sciences (13.7 percent), respectively.

The findings for the Health Sciences industry—an area commonly cited for its growth and growth potential— also provide interesting insight into the adoption of TBL strategies. While Githens et al. (2012) finds that Health Sciences comprise about 14 percent of technology-only community college programs, Gan et al. (2013) found that Health Care programs comprise nearly 50 percent of all the largest

---

[17] A discussion on evaluations of Digital Tutor's effectiveness is provided in the next chapter.

publicly funded training programs. Given the industry's large presence among all programs, one might have expected it to comprise a larger share of TBL programs as well. Interestingly, the STEM (science, technology, engineering, and math) Career Cluster accounted for less than 1 percent of all TBL programs surveyed by Githens et al. (2012).

That these industries are not more commonly represented by TBL programs may be attributable to difficulties associated with adapting relevant coursework to TBL environments. This is supported by Githens et al. (2012) who concluded that TBL programs are more prevalent in subjects that are more easily adapted from classroom-based instruction to technology-only instruction. Conversely, those subjects with higher technical or hands-on content take longer to design or adapt for technology-only instruction. Consistent with this hypothesis, Gan et al. (2013) found that TBL was more likely to be used in the IT industry than in Health Care, which must incorporate significant clinical and lab-based competencies.

Expanding on this profile of programs relying on a TBL format are data that summarize the prevalence of TBL within CTE, developmental education, or higher education more generally. For community colleges, generally, the International Technology Council (ITC) administers a distance education survey to all members of the American Association of Community Colleges. In 2013, the survey received responses from 142 member institutions. The survey reported on the prevalence of blended and technology-only (i.e., completely online) course formats among these institutions.[18] In 2013, 58 percent of respondents offered technology courses (compared to 63 percent in 2012). Fourteen percent offered blended or hybrid courses (compared to 27 percent in 2012).[19] Also reported in the survey are the percentages of respondents currently offering certain technologies: Web conferencing or Webinars (80 percent), live lecture capture (51 percent), and Massive Open Online Courses (3 percent) (Lokken and Mullins 2014).

TBL is also used in other post-secondary educational institutions. The National Center for Education Statistics (NCES) has administered four separate surveys devoted to the topic of TBL among a nationally representative sample of post-secondary institutions. Known as Postsecondary Education Quick Information System (PEQIS) surveys, this collection of findings from point-in-time surveys sheds some light on the changing nature of TBL among different types of post-secondary institutions or state higher education agencies.[20] The first of these surveys was administered in 1995 and provides the first nationally representative data about TBL course offerings in higher education institutions. For the 1995 PEQIS survey, TBL (i.e., "distance education") was defined as instruction delivered remotely via audio, video, or

---

[18] The ITC survey defined a blended or hybrid course as one in which 30 to 79 percent of the content is delivered online, with online discussions and some face-to-face meetings. A Web-facilitated course (also known as Web-enhanced or Web-assisted) is a face-to-face program that incorporates the Internet to facilitate activities; one to 29 percent of the content is delivered online.

[19] Authors speculate that part of the reason for the decrease is that the most recent survey reported on the prevalence of a new item not in the previous surveys: Web-assisted courses, which 39 percent of respondents offered in 2013.

[20] The PEQIS was established in 1991 by NCES and is designed to conduct brief surveys of post-secondary institutions or state higher education agencies on post-secondary education topics of national importance. For more information on PEQIS surveys, see http://nces.ed.gov/surveys/peqis/index.asp.

computer technologies.[21] Since then, additional surveys have been administered in 1998, 2002, and 2007. Importantly, the surveys are not specifically designed to make claims about longitudinal trends among a cohort of schools due to changes in the sample, the evolving definition of TBL, and refinements to the survey questions over time. However, this series of surveys can be used to provide very informal "mile markers" in the adoption of TBL within the CTE system.

In the mid-1990s, TBL was already quite common among public two-year institutions, but over a relatively short period of time, TBL courses became nearly ubiquitous. In 1995, 58 percent of public two-year institutions were offering technology-only courses, just behind the 62 percent of public four-year institutions doing the same (Lewis, Alexander, and Farris 1997). By the 2000-2001 academic year, a subsequent survey of post-secondary institutions reported that TBL courses were being offered by 90 percent of public two-year institutions and 89 percent of public four-year institutions (Tabs 2003). Since then, the prevalence of TBL courses has continued to grow among public two-year institutions, 97 percent of which offered such a course in 2006-2007, but remained unchanged among four-year schools (Parsad and Lewis 2008). However, these data do reflect the adoption of a somewhat expanded definition of TBL.[22] In every year, both two-year and four-year public schools outpaced all other institutional types in offering TBL courses. Particularly noteworthy is the comparatively limited prevalence of TBL offerings among private for-profit, two-year institutions. By the 2006-2007 survey, less than one in five (18 percent) of these institutions reported offering TBL (Parsad and Lewis 2008). This finding is underlined by the fact that the 2006-2007 survey used a more inclusive definition of TBL than did previous PEQUIS surveys. However, these data should be interpreted with caution since NCES has not issued a subsequent PEQIS survey on the topic of TBL among post-secondary institutions since the 2006-2007 iteration.

While these PEQIS surveys indicate that nearly all public two-year institutions offer TBL, they generally lack detail about the types of courses being offered, or about the institutions themselves. However, a 2004 report from a one-time survey of community colleges found that about 75 percent of these institutions offer CTE courses using TBL), confirming that TBL is common in subject areas and fields that are of particular interest to the public workforce system (Johnson et al. 2004). The most common occupation-specific CTE course in 2004 was keyboarding, taken by 25 percent of public high school graduates (Dalton et al. 2013). These researchers also found that, compared with smaller schools, Internet-based, TBL CTE courses were offered at higher rates among larger colleges—over 3,000 students—and urban or suburban colleges. This reported urban-rural difference is noteworthy, given early speculation that rural schools may be more inclined to adopt TBL strategies so as to address issues of geographic access and reach. Still, 10 years later, there can be little doubt that virtually every community college now offers some course using some type of TBL. In 2006-2007, 96 percent of public community colleges offered one or more online courses (Parsad and Lewis 2008).

---

21 Considered TBL by this literature review because the survey respondents could categorize blended learning as "distance learning" and the survey did not differentiate between technology-only and blended learning.

22 For the 2008 NCES report, technology-only education was defined as a formal education process in which the learner and instructor are not in the same place. Thus, instruction may be synchronous or asynchronous, and it may involve communication through the use of video, audio, or computer technologies, or by correspondence (which may include both written correspondence and the use of technology such as CD-ROM). Between the 2000-01 and 2006-07 surveys, NCES altered the definition of "distance education" used for the survey, so the changes in prevalence of technology-only education could be attributed to that change in definition rather than real changes in course offerings at post-secondary schools.

Another step in the integration of TBL into career and technical education is the development of full programs of study (composed of multiple courses) that rely extensively on TBL. PEQIS defines TBL programs, broadly, as those that are designed to be completed entirely through TBL and that culminate in a degree or certificate. However, as the definition of TBL courses has shifted over time, so too has the definition of TBL programs. The PEQIS data below provides some useful snapshots of TBL use over time and only general indications of trends.

TBL programs are less prevalent than are individual TBL courses. Nonetheless, they have experienced considerable growth over time. Roughly 45 percent of public two-year institutions offered TBL programs in the 2006-2007 year, up steadily from 22 percent in 2000-2001 and only 8 percent in 1997-1998 (Parsad and Lewis 2008; Tabs 2003; Lewis et al. 1999). More recent data come from the ITC (2014) survey of community colleges in 2013. According to the survey, 87 percent of respondents reported offering at least one distance education degree. [23]

Exhibit 3: TBL Programs Culminating in a Degree or Certificate

Institutional type and size	Total number of programs designed to be completed entirely through TBL	Percent of total TBL programs					
		Degree programs			Certificate programs		
		Degree programs at either level	Under-graduate degree programs	Graduate/ first-professional degree programs	Certificate programs at either level	Under-graduate certificate programs	Graduate/ first-professional certificate programs
All institutions	11,240	66	41	25	34	22	12
Institutional type							
Public 2-year	3,590	50	49	NA	50	50	NA
Public 4-year	3,550	69	29	40	31	10	21

NOTE: Detail may not sum to totals because of rounding.
SOURCE: Parsad, Lewis, and Tice 2008, 11.

As discussed above, two-year public institutions were slightly more likely than four-year institutions to offer individual TBL courses. However, the reverse is true for TBL programs (Lewis, Alexander, and Farris 1997; Parsad and Lewis 2008; Tabs 2003). Public four-year institutions appear to have been consistently more likely to offer a TBL program, but that gap narrowed in the most recent NCES survey (e.g., Exhibit 3, from the Parsad and Lewis 2008 surveys). In addition, two-year and four-year schools differ in their tendency to offer TBL programs that culminate in a degree rather than a certificate. As expected, TBL programs at four-year schools were more likely than two-year programs to culminate in a degree. The split between TBL degree and certificate programs is roughly 50/50 among two-year institutions and roughly 70/30 among public four-year institutions (Parsad and Lewis 2008). Githens et al. (2012) confirmed that this roughly 50/50 split has persisted specifically among TBL occupational programs in community colleges. The ITC found that, in 2013, 81 percent of community college respondents indicated their institution offered an online certificate or degree (Lokken and Mullins 2014).

[23] This number dipped slightly from 90 percent in 2012, but increased from 78 percent in 2011. In 2006, the figure was 64 percent (ITC 2014).

Nonetheless, the availability of TBL courses and programs does not necessarily imply that these resources are in use. For example, while more than two-thirds of all post-secondary students attended a school that offered TBL courses in 2006, only 20 percent of students were enrolled in at least one TBL course at this time (Allen and Seaman 2014).[24,25] Moreover, only 4 percent of undergraduate students were enrolled in a TBL degree program in 2007-2008 (Parsad and Lewis 2008). Still, TBL enrollment has continued to increase every year, and about 33 percent of post-secondary students were enrolled in a TBL course as of 2012, an increase that may be attributable to more TBL courses being offered or an increase in take-up of existing TBL courses (Allen and Seaman 2014). While the primary driver of this growth cannot be conclusively identified, Chapter 3 discusses some of the factors that affect the learner's decision to take up TBL and the provider's decision to offer it.

The design of TBL within two-year colleges. The research discussed above suggests a steady pace of adoption of technology-only TBL. However, this story is not only one of increased prevalence and utilization but also of a dynamic mix of technologies in use. The most salient characteristic of this change has been the rapid adoption of Internet-based technologies to deliver TBL. Moreover, public two-year institutions offering TBL turned toward those Internet-based technologies that enabled more flexible, asynchronous learning.

Nearly two decades ago, NCES found that in 1995 most public two-year institutions offering TBL were using more established audio and visual media, such as one-way pre-recorded videos (67 percent) or two-way interactive videos (49 percent) (Lewis, Alexander, and Farris 1997). At that time, about three-fourths of all institutions planned to start or increase their use of the more interactive of these technologies as well as Internet-based technologies to deliver their TBL courses.

Two years later, the distribution of technology use was roughly unchanged, with one major difference: the use of the Internet had taken off.[26] The share of two-year schools using asynchronous, Internet-based technologies had more than quadrupled, from 14 percent of institutions in 1995 to 59 percent in 1997 (Lewis, Alexander, and Farris 1997; Lewis et al. 1999). Use of synchronous, Internet-based technologies—in use at 16 percent of institutions offering technology-only education—had doubled since 1995 but lagged behind asynchronous technologies in 1997. Still, one-way, prerecorded video continued to be the most widely used medium by public two-year institutions (64 percent).

In the following 10 years, the increasing use of asynchronous Internet-based technologies in technology-only education continued to outpace that of all other technologies surveyed. In fact, by 2006, a vast majority (93 percent) of public two-year institutions offering technology-only education used

---

[24] Based on the most recent NCES report, about two-thirds of all post-secondary institutions offered a technology-only education course. Since the largest schools were the most likely to offer a technology-only course, this implies that more than two-thirds of all learners were enrolled at schools that offer technology-only courses.

[25] Note that this is not the ideal unit of analysis for this comparison of use versus availability. More detailed data might identify the share of available technology-only education learning hours that are taken up by learners. However, those data are not available for institutions of higher education.

[26] For its 1999 report, NCES began reporting on two new categories of technologies for technology-only education delivery: synchronous and asynchronous Internet-based technologies. These were comparable to and thus essentially replaced two categories from the previous report: "two-way online (computer-based) interactions" and "other computer-based technology (e.g., Internet)", respectively.

asynchronous, Internet technologies to a moderate or large extent, while about 30 percent used synchronous Internet technologies or two-way interactive video, and the percentage using one-way, prerecorded videos had dropped to 21 percent (Parsad and Lewis 2008).[27] Given the apparent preference for asynchronous, Internet technologies over all others, including synchronous, Internet-based technologies and two-way, interactive videos, institutions of higher education seem to have turned to the Internet as a means to enable and facilitate flexible learning in their technology-only education courses.

Finally, in a study of recent instructional reforms made to developmental education programs, researchers at the Community College Research Center (CCRC) found that 24 percent of innovations identified in community colleges (16 of the 66 total) were characterized as modularizations, which typically use computer software to reorganize existing curriculum into smaller, discrete units that learners are able to access at their own pace (Edgecombe et al. 2013).

4.2.6 Prevalence and Use of TBL Within Adult Education

There is growing evidence of the use of TBL within adult education programs. A national study of adult education programs, from 2007, found that nearly 90 percent used some form of computer-assisted instruction and approximately 70 percent used multimedia learning labs or centers (Tamassia et al. 2007).[28] While the use of these learning environments was widespread across providers, it was not necessarily a major component of their instruction: approximately 15 percent of programs used TBL "a great deal" (for at least 30 percent of instruction time). Approximately two-thirds of the programs reported using other forms of technology, particularly video series (e.g., GED on TV and computer, Workplace Essential Skills[29]). Since then, a greater emphasis has been placed on the use of technology. For example, in early January 2014, the American Council on Education partnered with Pearson and created a revised, more challenging computer-based GED test (Adams 2014). Forty states and the District of Columbia offer the new GED, though10 states have dropped it due to price increases and increased difficulty in the test (Smith 2014).

Beyond these national-level data, most information on the use of TBL for adult education comes from states. The data from two states, Louisiana and Pennsylvania, are described below to provide some insights into the use of TBL from instructors' and learners' perspectives.

To determine the extent to which technology had been integrated into instruction by adult education teachers in 2004, Kotrlik and Redmann (2005) surveyed a random sample of adult education instructors at public secondary schools in Louisiana.[30] Categorizing the extent of technology integration by instructors,

---

27 Note that NCES changed the way it reported the use of technologies in its 2008 report. Whereas previous reports identified the share of institutions that use various technologies as the primary mode of instruction in a course, the most recent report identified the share of institutions that use various technologies to a moderate or large extent in a course.

28 The providers of adult education were located in local education agencies (54 percent), community-based organizations (24 percent), community colleges (17 percent), correctional institutions (2 percent), and other (3 percent).

29 A work-readiness and life skills curricula for adults

30 At the time of publication, the authors noted that no data could be found that described technology use specifically by adult education instructors.

the authors found that most of the GED preparation instructors surveyed were just beginning to use technology, seeking out information about it, and considering its use. These teachers identified themselves as having made evident changes to the classroom, employing presentation software and instructional exercises using technology, and encouraging learners to share in the responsibility for learning. The survey also found that adult education teachers had not yet progressed to advanced or innovative integration of technology, characterized by encouraging learners to use technology to collaborate with others and take on new challenges beyond traditional assignments and activities.

Turning from the instructor-level experience to the learner-level, Prins et al. (2012) surveyed GED learners in state-funded programs in Pennsylvania. Since 2001, the Pennsylvania Department of Education's Division of Adult Education has administered technology-only based learning for adults, emphasizing basic education, GED preparation, and workplace skills. The data showed that only 4 percent of rural GED learners in state-funded programs participated in TBL programs, about 75 percent of whom participated in a blended learning environment rather than a technology-only learning program (Prins et al. 2012). Combining the data from both blended and technology-only programs, typical learners in that survey spent about 40 percent of their instructional hours in a TBL environment.

4.3 Summary

There is increasing utilization of TBL across the myriad programs and investments in public, non-profit, and private sector agencies and organizations which contribute to workforce training and education in the United States. At the Federal level, the two agencies that provide the most significant funding for workforce training and education, DOL and ED, have each encouraged and supported the use of technology-based learning. DOL's major efforts include the multipronged TBL Initiative, the creation of the E-tools, and, more recently, the creation of the SkillsCommons. ED has developed a broad vision of ways technology can be incorporated into teaching and learning and has invested in research centers with significant TBL components, like the Center for the Analysis of Postsecondary Readiness, the Center for the Study of Adult Literacy, and the Advanced Research Projects Agency-Education (ARPA-ED). The data on use and prevalence suggest significant uptake of TBL for workforce services, training and education. However, the empirical data is segmented by training provider and hampered by the use different data sources, with differing definitions of TBL.

5. Empirical Evidence on the Use of TBL for Improving Workforce Outcomes

Chapter 5 reviews some of the available empirical evidence of the effectiveness or promise of TBL for improving workforce-related outcomes. To date, there has been little rigorous research in this area, though researchers have published meta-analyses on the effects of TBL for broader educational and learning outcomes (Means et al. 2010; Bernard et al. 2009; Sitzmann et al. 2006; Sitzmann 2011). However, there have been no similar meta-analyses examining the efficacy of TBL for employment-related outcomes, such as building work-related skills, which led to obtaining and retaining employment in populations comparable to those commonly served through the public workforce system. In the absence of such meta-analyses, this chapter more narrowly examines the questions of “What is the empirical evidence for the effectiveness of particular TBL programs for improving workforce-related outcomes?”

The chapter is organized around a fundamental distinction in TBL (discussed in Chapter 2): the extent to which technology is paired with traditional instructional methods.

- The first section synthesizes the findings from comparisons of traditional classroom-based learning with interventions that use technology-only learning. Interventions are categorized as technology-only if the entire learning process is completed using technology-based resources. This includes, for instance, a course that requires learners to work independently in a computer lab during a designated class time.
- In contrast, blended interventions are those that use technology-based resources and traditional resources such as face-to-face instruction and printed materials. The following section considers blended interventions that synchronously combine technology and traditional instruction. In the literature included in this review, these interventions often involve the combination of computer-based and classroom learning environments.

These sections progress, generally, from models that limit interpersonal interaction to those that encourage it, through the use of technology or by incorporating elements of traditional classrooms.

Finally, while the literature examines suggestive, and sometimes causal, evidence of the efficacy of TBL programs, the research generally provides limited evidence as to how or why key outcomes or impacts are generated. To the extent possible, this chapter seeks to extract some lessons for program design from the empirical literature, but this evidence is often weak. Except for a small number of multi-arm randomized control trials, which rigorously compare varying types of TBL to one another, discussions of the effective features of an intervention should be interpreted as merely suggestive.

Each of the 28 studies discussed provides insight into the effects of technology-based learning by comparing the difference in outcomes between individuals with the opportunity to engage in TBL and those without. Specifically, these randomized control trial (RCT) and quasi-experimental design (QED) studies, compare outcomes of a treatment group either to those assigned to an alternative treatment or to those of a comparison or control group. While this literature would ideally examine direct effects of TBL on workforce outcomes, such as employment status and wages, such data are typically not available. Since tracking and measuring change on these long-term outcomes takes considerable time, most of the literature (and thus the review) focuses on more proximal measures of impact such as skills or knowledge accumulation, learner satisfaction or experience and behavioral changes related to work.

In addition to their use of rigorous evaluation designs, the studies highlighted in this chapter focused on learners that were sufficiently comparable to the population of individuals commonly served through the public workforce system. Thus, the samples included in the studies generally consist of adults enrolled in two-year colleges, incumbent workers, adults in the public workforce system, and adults in continuing or remedial education.[31] Finally, it should be noted that, given the dearth of rigorous research, the review errs on the side of inclusiveness, even though some of the studies identified were conducted more than a decade ago. Given the relentless evolution of technology and TBL, it is not clear how well the findings from older studies generalize to the current context. While they may provide some insight into the evolving focus both the use of technology and the research, these older findings should be interpreted cautiously.

5.1 The Effectiveness of Technology-only Interventions for Improving Workforce-related Outcomes

As discussed in Chapter 2, there are a number of dimensions that may characterize TBL. The earlier versions of TBL primarily varied by whether instruction occurred at a fixed time and space (synchronous versus asynchronous). As the technologies and platforms evolved, more sophisticated distinctions emerged such that TBL may also vary in, for instance, the amount of interaction between learners and instructors, learners and content, and among multiple learners. Despite the expanding dimensions of TBL the discussion that follows presents research findings according to the synchronicity of the learning experience and the flexibility that it affords learners in terms of both time and space. This organizational construct reflects two important factors. First and foremost it best captures the nature of the TBL designs that are highlighted in the empirical literature. Secondly, relative to the traditional education system, adult learners in the workforce development system are more likely to face barriers and constraints on their time, making the time and space flexibility of TBL a particularly important consideration.

Interventions are generally characterized as asynchronous if they predominantly occur according to the learner’s own time or location. That is, they allow learners to complete course requirements outside of a pre-determined time or location.[32] In such programs, learners are able to complete their work on their own time and from their location of choice. Conversely, interventions are categorized as synchronous if they occur predominantly in a set time and space. Synchronous interventions are those that require learners to work at a specified time or from a specified location, typically a classroom during a school day. As the chapter unfolds, these categories of technology-only/blended and synchronous/asynchronous intersect in that they each imply certain constraints or opportunities for interpersonal interaction during the learning process. While asynchronous technology-only interventions can (but do not necessarily) operate

31 Note that this literature review does not focus on studies of the use of TBL for samples of students in the K-12 system or the four-year undergraduate or graduate post-secondary system.

32 Note that under this framework, interventions that allow learners to work at their own pace are not necessarily asynchronous if learners are required to complete that course during a specified time. In this case, the interventions are categorized as *not* offering learners a kind of flexibility in terms of time, i.e., synchronous.

completely independently of interpersonal interactions, it would be implausible to offer synchronous technology-only or blended interventions without interaction.

5.1.1 Asynchronous, Technology-only Interventions

Asynchronous, technology-only interventions include the prototypical distance education model. Given this history of this instructional strategy, most evaluations of TBL compare the effectiveness of these interventions—typically an online class—to those from a traditional classroom. There is mixed evidence for the impacts of asynchronous, technology-only interventions for workforce-related learning outcomes and attitudinal, behavioral, or perception outcomes (Exhibit 4).

Exhibit 4: Rigorous Studies of Asynchronous, Technology-only Interventions (v. Traditional Interventions)

Study	Intervention Summary	TBL	Impacts
Hairston, 2011 RCT	Supervisory skills for incumbent workers	Technology-only Asynchronous Content-centric No interaction	NS learning - satisfaction
Lowry, 2007 RCT	Implementation of a new instructional strategy for K-12 teachers	Technology-only Asynchronous Content-centric Full-group interaction	+ interaction time NS teacher performance NS interaction quality NS frequency of implementation NS level of implementation.
Shea, 2014 QED	Online and distance education in a community college	Technology-only Asynchronous *Course content not specified* *Interaction type not specified*	+ degree attainment subsequent to attending a distance/online course
Van Rooij, 2007 RCT	Problem-solving knowledge and self-efficacy for business research methods course learners	Technology-only Asynchronous Learner-centric Learner-learner interaction	+ problem-solving knowledge + learner perceived learning benefits NS problem solving self-efficacy
Xu and Jaggars, 2013 QED	Academic achievement for community college students on "academic transfer" track	Technology-only Asynchronous *Course content not specified* *Interaction type not specified*	- course grade

Notes:
In Column 1: RCT indicates that the study used a randomized control trial design; QED indicates that the study used a quasi-experimental design.
In Column 4: "+" indicates a positive significant impact; "NS" indicates no significant impact; "-" indicates a negative significant impact.

Three of the studies reviewed found that asynchronous, technology-only interventions were at least as effective as traditional interventions for improving workforce-related outcomes. Using a nationally representative sample, Shea (2014) found that learners who had completed a technology-only course early in their community college career were more likely to subsequently earn a degree than were those who had only traditional classwork. This is based on a broad sample of community college students who either took an online course or enrolled in classroom-only experiences in their first year. These individuals were propensity-score matched on the basis of demographics, educational background, educational pathway (e.g., nature of coursework, amount of loans), family background, and institutional characteristics. Van Rooij (2007) found positive impacts of asynchronous, technology-only TBL relative to the use of a similar self-paced course without that technology. In this RCT, working adults seeking to advance their careers through a business and management education program were randomly assigned to use either an online software application to supplement a text-based workbook or just the workbook. The software allowed users to navigate their own path through course material, encountering multimedia resources and external Websites for additional exploration; the software was also used in the completion of a course project. On the course's final exam, learners who used this software outperformed their counterparts who completed the course using a text-based workbook only. Similarly, Lowry (2007) conducted an RCT of an in-service teacher professional development program, delivered either remotely and asynchronously or in a traditional classroom environment, meant to prepare teachers to use a new instructional strategy.[33] After randomly assigning participants to each condition, there were no significant differences in the extent to which teachers used the instructional strategy after completion of the program.

Two other studies found that asynchronous, technology-only interventions were no better than, and in some cases less effective than, traditional interventions for improving workforce-related outcomes. Like much of the literature cited above, Hairston (2011) reports no significant differences in content knowledge gains between participants in a typical asynchronous technology course and those in a traditional environment. However, findings were negative with regard to satisfaction outcomes: the extent to which participating employees liked their given course and found it relevant. The traditional classroom group reported higher levels of general program satisfaction and satisfaction with method of instruction. The two groups were statistically equally satisfied with course content. Likewise, Xu and Jaggars (2013) report significantly lower learning outcomes in a technology-only environment for community college learners.[34] In this study, with an instrumental variables model, the distance from a student's home to his/her community college campus is used like a proxy for technology-only course attendance. The authors estimate negative impacts of technology-only course enrollment on course grade. However, because the authors restricted their analysis to community college students in an "academic transfer" track rather than a career-and-technical education track, these findings may not be as germane to the population of individuals most likely to be served by the public workforce system.

5.1.2 Design Features of Promising Asynchronous, Technology-only Interventions

A feature of asynchronous, technology-only interventions that appears consistently throughout the empirical literature is the extent to which learners are engaged and active throughout the duration of the course. Most of the literature finds that interventions that increase active engagement in either the content of the course or with other learners are related to improved workforce outcomes. Across asynchronous,

---

33 The intervention was primarily asynchronous but did allow for synchronous online discussion.

34 Authors do not provide much description on the characteristics of the online classes offered at the community colleges studied. Courses are assumed to be asynchronous since the community colleges describe the courses in the following way, "Since you don't have to be in class at a certain time, you can fit your coursework into your schedule." (http://distanceed.highline.edu/waol.php, accessed March 6, 2014).

technology-only interventions, designers are using technology to increase learner engagement and, ultimately, instructional effectiveness.

First, rigorous tests show that asynchronous, technology-only interventions are as or more effective if they include active engagement with and control over content than if they do not (Exhibit 5). Segal and his co-authors (2003) found no significant differences in knowledge gains among adults randomly assigned to learning new parental strategies in a course that required the active completion of quizzes versus those assigned to watch a non-interactive videotape of the same material. Howard-Jones and Martin (2002) found positive impacts from learner-centric asynchronous, technology-only interventions using a quasi-experimental design. In this case, when pre-service teachers in an asynchronous, technology-only course online were required to construct their own understanding of the course material and generate course content, they demonstrated learning gains that were about 40 percent larger on average than gains demonstrated in the same course with content presented to them with example problems and solutions. However, both of these tests are at least a decade old, so generalizations to the impacts of current TBL should be made with caution.

Exhibit 5: Rigorous Studies of Design Features of Asynchronous, Technology-only interventions

Study	Intervention Summary	TBL	Impacts
Howard-Jones, 2002 RCT	Pedagogical knowledge for pre-service teachers	Contrast: actively requiring a response (v. no response) In both cases: Technology-only Asynchronous Content-centric No interaction	+ learning
Segal, 2003 RCT	Parenting skills for at-risk families	Contrast: interactive multimedia (v. non-interactive videotape) In both cases: Technology-only Asynchronous Content-centric Limited/no interaction	NS parenting knowledge NS satisfaction NS children's behavior

Notes:
In Column 1: RCT indicates that the study used a randomized control trial design; QED indicates that the study used a quasi-experimental design.
In Column 4: "+" indicates a positive significant impact; "NS" indicates no significant impact; "-" indicates a negative significant impact.

Interaction also appears to be an important design feature of asynchronous, technology-only programs. Two studies that involved collaboration and communication among peers found that the quality of communication was as good or better in a TBL environment when compared to a control group that did use technology. However, these findings are merely suggestive since they are based on studies that examined the efficacy of asynchronous, technology-only relative to traditional learning, rather than comparing various TBL interventions. Learners in the Van Rooij (2007) study above reported using technology to engage with course content and peers, resulting in self-reported high-quality interaction and, ultimately, learning. Similarly, Lowry's (2007) study of interventions for pre-service teachers, discussed above, highlighted how asynchronous, technology-only programs may increase interactions relative to a traditional classroom program. Learners assigned to a remote, asynchronous environment actually interacted with each other twice as much as did their peers in the traditional program. In this case, technology and the ability to communicate asynchronously facilitated increased interactions between learners, through e-mail, discussion boards, and online chat rooms.

5.1.3 Synchronous, Technology-only Interventions

Similar to the findings cited above for asynchronous, technology-only interventions, the existing evidence for the effects of synchronous, technology-only programs on workforce-related outcomes is mixed (Exhibit 6). However, of the six studies identified, each intervention was at least as effective as traditional education in affecting workforce-related learning. Among the six studies of synchronous, technology-only interventions, the only significant negative findings are related to self-reported satisfaction, motivation, and attitudes. Synchronous, technology-only interventions are those in which participants have limited or no flexibility in the time and location in which they access instruction. A prototypical example of such interventions is one that requires participants to use class time in a computer lab to complete a technology-only module. While learners may control the pace of material within the allotted time, this model is considered synchronous since there are narrow and finite bounds on how and where learners can access the content. These interventions bridge the technology-only and blended categories in that they are often tested as a supplement to a traditional class (e.g., a traditional class with TBL versus the traditional class alone).

Some of the initial evidence in support of synchronous technology-only TBL dates back to the 1990s, when researchers using a quasi-experimental design found that a series of self-paced e-learning modules were more effective than traditional literacy instruction in promoting learning gains in a matched comparison group of ABE learners (Gretes and Green 1994). These modules presented content to learners and allowed them, at their own pace, to request the definitions and pronunciations of unfamiliar words while they were learning literacy skills like summarization, scanning, and vocabulary development. One newer study similarly found somewhat positive workforce-related impacts for synchronous, technology-only interventions. Beeckman et al. (2008) examined the effectiveness of a one-hour, technology-only program for improving the ability of student nurses and working nurses to classify certain medical conditions compared to their randomly assigned counterparts who participated in a traditional, one-hour lecture on the same topic. There were positive impacts for nursing students participating in the TBL program and no significant differences for working nurses.

In contrast, three other studies find negative or neutral impacts for synchronous, technology-only interventions. Fisher (1999) found no significant differences in learning outcomes for pre-service and in-service teachers randomly assigned to be taught the same content using either a live workshop or a virtual workshop based in an interactive multi-media program with text, video, animation and graphics. However, TBL learners also reported significantly lower levels of satisfaction with concept mastery than did the control group. Likewise, Schmeeckle (2003) finds neutral or negative impacts from synchronous, technology-only learning. In that study, there were no significant differences in learning between law enforcement personnel randomly assigned to a computer lab using online modules and those taught in a traditional classroom. However, the synchronous, technology-only group did report lower levels of motivation and less positive attitudes after completing their training than did the classroom group.

Finally, there were significant cost-efficiencies to the TBL: the online training was completed in about half the time as the traditional instruction and at a lower cost.

As was discussed above, researchers and program designers are often interested in the extent to which program impacts vary with the characteristics of participants. The literature covered in Chapter 3 hypothesizes a number of barriers and challenges that learners face when participating in a TBL course. However, there is mixed evidence in support of the hypothesis that previous knowledge of course content and pre-program education level affected a learner's likelihood of completing a TBL course (Aragon and Johnson 2008; Muse Jr. 2003; Park and Choi 2009). In general, impact evaluations for this review do not explore subgroup-specific impacts by pre-program education level or degree of technological literacy. While none of the evaluations of asynchronous interventions discussed above were able to address this and other subgroup analyses, two evaluations cited here do so. In Gretes and Green's (1994) quasi-experimental study, the estimated workforce-related impacts among adults with lower levels of literacy were comparable to those of adults with higher levels of literacy before attending adult education.[35] In addition, Schmeeckle (2003) stratified her sample according to pre-program education level and compared outcomes for all participants, thereby shedding some light on the relationship between educational background plays and learning within both types of classroom environments. She found no significant differences between law enforcement personnel with high school degrees, some college, and bachelor's degrees in pre-test scores, post-program scores for individual units, or instructional time. However, those with a high school degree only scored significantly lower in terms of their total course grades (courses consisted of multiple units) than did those with any college or a bachelor's degree.

Exhibit 6: Rigorous Studies of Synchronous, Technology-only interventions (v. Traditional Interventions)

Study	Intervention Summary	TBL	Impacts
Beeckman 2008 RCT	Classification skills for nurses and nursing students	Technology-only Synchronous Content-centric No interaction	+ classification skills for nursing students NS classification skills for nurses
Eckerman, 2002 RCT	Respiratory protection knowledge for adults	Technology only Synchronous Learner-centric and content-centric No interaction	NS learning
Fisher, 1999 RCT	Pedagogical knowledge for pre-service and in-service teachers	Technology-only Synchronous Content-centric No interaction	NS learning and implementation -satisfaction ratings in terms of concept mastery
Gretes, 1994 QED	Literacy skills for ABE learners	Technology-only Synchronous Content-centric No interaction	+ learning, larger for those who completed relatively more modules

35 Authors did not examine whether groups differed in levels of technological literacy.

Study	Intervention Summary	TBL	Impacts
Rohlman, 2004 Studies 1 and 2 RCT	Respiratory protection knowledge for adults	Technology-only Synchronous Content-centric No interaction	NS learning
Schmeeckle, 2003 RCT	Jail management knowledge for incumbent workers	Technology-only Synchronous Content-centric Instructor-learner interaction	NS learning -motivation and attitude impacts

Notes:
In Column 1: RCT indicates that the study used a randomized control trial design; QED indicates that the study used a quasi-experimental design.
In Column 4: "+" indicates a positive significant impact; "NS" indicates no significant impact; "-" indicates a negative significant impact.

5.1.4 Design Features of Promising Synchronous, Technology-only Interventions

The interventions covered in this section shared a number of similar strategies or components. Just as in asynchronous environments, these synchronous, technology-only programs often encouraged learners to be active during the learning process (Eckerman et al. 2002; Rohlman et al. 2004; Gretes and Green 1994; Beeckman et al. 2008; Fisher, Deshler, and Schumaker 1999; Nicol and Anderson 2000). To that end, these programs also typically required participants to complete some sort of review quiz or set of practice exercise questions, and while these exercises typically took the form of multiple choice questions, some (e.g., Schmeeckle 2003) required written short answers from learners.

Exhibit 7: Rigorous Studies of Design Features of Synchronous, Technology-only Interventions

Study	Intervention Summary	TBL	Impacts
Eckerman, 2002 RCT	Respiratory protection knowledge for adults	Contrast: learner-centric TBL (v. content-centric TBL) In both cases: Technology only Synchronous Learner-centric and content-centric No interaction	+ learning
Rohlman, 2004 Studies 1 and 2 RCT	Respiratory protection knowledge for adults	Contrast 1: TBL w/interactive Q&A (v. TBL w/ passive Q&A) Contrast 2: TBL with Q&A (v. TBL w/o Q&A) In all cases: Technology-only Synchronous Content-centric No interaction	NS learning (Contrast 1) + learning (Contrast 2)

Notes:
In Column 1: RCT indicates that the study used a randomized control trial design; QED indicates that the study used a quasi-experimental design.
In Column 4: "+" indicates a positive significant impact; "NS" indicates no significant impact; "-" indicates a negative significant impact (.Eckerman 2002 and Rohlman 2004 also tested TBL v. traditional—see Exhibit 6).

However, only two of these interventions attempted to directly test the impact of learner activity through practice questions and sample problems (Exhibit 7). Rohlman (2004) and found that learners perform comparably in a TBL environment when they are randomly assigned to complete practice exercises and when they merely observe solutions to practice exercises. In other words, the act of answering a given question and receiving feedback did not yield improved outcomes relative to passively observing answers that were provided by the module. Nonetheless, in both studies, learners demonstrate improvements in learning outcomes when exposed to sample problems with solutions, and these improvements exceed those of learners in an environment that merely presents course content without any sample problems and solutions. This finding implies that learners in synchronous, technology-only programs benefit from some form of practice work and feedback (Eckerman et al. 2002; Rohlman et al. 2004). However, these findings are at least a decade old, so generalizations to current technologies and TBL should be made with caution.

While nearly all of the synchronous TBL interventions identified for this review did not allow learners to work at any time of their choosing, implying some inflexibility in time, they did commonly allow learners to work at their own pace. A typical intervention required learners to attend a computer lab during an assigned class period, but learners had the flexibility to take different amounts of time to complete their work. However, none of the studies identified for this review explicitly tested a self-paced TBL intervention against a comparable alternative that did not allow for self-paced work.

Finally, the studies also include suggestive findings about the relationship between engagement and instructional effectiveness. In any TBL environment, it is also important to consider the “dosage” or amount of time learners spend in the intervention when thinking about program impact (Gretes and Green 1994; Li and Edmonds 2005). Due to the nature of self-paced learning, there can be wide variations in the amount of time that program participants spend in the learning environment. While few of the studies in this review were able to test this nuance explicitly, Gretes and Green’s (1994) early study found that significant impacts did not manifest until participants completed more than one course module. In addition, while Li and Edmonds’ (2005) quasi-experimental study is included in the discussion of blended interventions below, the authors did report that learners in a computer-assisted instructional environment were more likely to find the technology helpful as they attended computer lab classes more frequently. In this case, students self-selected the number of classes attended.

5.2 The Effectiveness of Blended Interventions for Improving Workforce-related Outcomes

In contrast to the findings for technology-only interventions, blended learning appears to be at least as effective as traditional learning for achieving improved workforce-related outcomes (Exhibit 8). In 11 of the 12 studies reviewed, blended interventions were at least as effective as traditional. In only one study were there significant negative impacts and while the blended intervention had negative impacts on attitudinal measures, there were no significant differences in learning (Bishop 2010).

As discussed below, the findings seem to depend in part, on the way in which technologies are blended with traditional learning. As described in Chapter 2, blended learning environments combine traditional classroom education—or any approach that does not involve technology—with technology. For example, an instructor-led lecture that requires learners to work from in-class computers would be considered blended, as would an online program completed at a learner’s home that incorporated some traditional work from a textbook or workbook. In some cases, learners were offered access to both traditional and technology-based learning opportunities, but the authors did not comment extensively on how much learners used or were required to use each type. Nonetheless, the joint presence of traditional learning and technology is considered a blending of the two strategies. Finally, blended interventions, almost by necessity, are at least partially synchronous in that they tend to require in-class attendance for the traditional portion of instruction.

Exhibit 8: Rigorous Studies of Blended Interventions (v. Traditional Interventions)

Study	Intervention Summary	TBL	Impacts
Batchelder, 2000 RCT	Reading and math skills for ABE inmates	Blended (substitution) Synchronous Learner-centric No interaction via tech	NS learning
Bishop, 2010 QED	Developmental mathematics education at a community college	Blended (substitution) Synchronous Content-centric Learner-learner interaction and Lerner-teacher interaction	NS learning - attitudinal
Burgess, 2010 QED	Developmental reading course at a four-year college	Blended (addition) Synchronous Content-centric Learner-learner interaction	+ learning
Fletcher, 2012 QED	IT knowledge for Navy technicians	Blended (substitution) Synchronous Learner-centric No interaction via tech	+ learning
Kummerow, 2012 QED	Mental health course for baccalaureate nursing students (with a clinical component)	Blended (substitution) Asynchronous Content-centric No interaction via tech	NS learning
Li and Edmonds, 2005 QED	Basic math skills for ABE learners	Blended (addition) Synchronous Learner-centric No interaction via tech	+ learning in 3of 6 unit tests + satisfaction and confidence NS learning in 3 of 6 unit tests and final grades
MANILA, 2008 QED	Literacy skills for ABE learners at Job Corps centers	Blended (substitution) Synchronous Content/Learner-centric Full-group interaction	NS literacy
McKane, 1996 RCT	Literacy skills for ABE inmates	Blended (substitution) Synchronous Content-centric No interaction	+ learning for low pre-program scores NS learning for high pre-program scores

Study	Intervention Summary	TBL	Impacts
Nicol, 2000 RCT	Basic math skills for adults with mild learning disabilities	Blended (substitution) Synchronous Content-centric Learner-learner interaction	+ learning
Parchman, 2000 RCT	Basic electricity and electronics training for Navy electronic technicians	Blended (substitution) Synchronous Content-centric and Learner centric Full group interaction	+ learning for two out of four outcome measures NS learning for two out of four outcome measures
Vulanovic, 2013 QED	Elementary math courses at a four-year college	Blended (substitution) Synchronous Asynchronous Content-centric Learner-teacher interaction	NS learning
Wladis, 2014 QED	Intervention to prevent course failure or dropout among remedial math learners	Blended (addition) Synchronous Content-centric *Interaction not specified*	+ pass rates

Notes:
In Column 1: RCT indicates that the study used a randomized control trial design; QED indicates that the study used a quasi-experimental design.
In Column 4: "+" indicates a positive significant impact; "NS" indicates no significant impact; "-" indicates a negative significant impact.

Like non-blended interventions discussed above, there are relatively few rigorous evaluations of blended learning models that target populations commonly served through the public workforce system. However, the empirical evidence suggests that blended interventions may be as effective, or more effective, than traditional interventions in supporting workforce-related outcomes (Batchelder and Rachal 2000; Fletcher and Morrison 2012; Li and Edmonds 2005; MANILA Consulting Group Inc. 2008; McKane and Greene 1996; Parchman et al. 2000; Rohlman et al. 2004; Lin 2013; Kummerow, Miller, and Reed 2012; Burgess 2010; Hrubik-Vulanovic 2013). In a number of cases, authors report no significant differences in outcomes between learners from blended or traditional environments (Li and Edmonds 2005; Batchelder and Rachal 2000; MANILA Consulting Group Inc. 2008; Kummerow, Miller, and Reed 2012; Bishop 2010; Hrubik-Vulanovic 2013). Others have identified large positive impacts, though some of this evidence must be interpreted with caution, as discussed below (Fletcher and Morrison 2012; Parchman et al. 2000; Lin 2013). Finally, others report nuanced evidence that varies with participant characteristics or the instrument used to measure outcomes (McKane and Greene 1996; MANILA Consulting Group Inc. 2008).

In two evaluations of blended learning environments, researchers report no significant differences in learning gains between treatment and control groups. In both cases, neither group demonstrated any gains in content knowledge (Batchelder and Rachal 2000; MANILA Consulting Group Inc. 2008).[36] Batchelder's (2000) RCT analyzed a blended program that cycled treatment group participants—inmates completing basic education courses—in and out of traditional and computer-based environments while comparison group participants remained in traditional classrooms only. In this analysis, there were small to no learning gains for either group and no significant differences between groups. However, this finding is more than a decade old, so it may not fully generalize to the current TBL environment. In a more recent analysis of the READ 180 blended learning program as it was implemented in multiple Job Corps Centers, researchers found that learners at participating centers and learners at matched, non-participating centers both showed no significant improvement on the Test of Adult Basic Education (MANILA Consulting Group Inc. 2008).

Three studies also report neutral impacts (no significant difference) for blended learning, but in these cases, the authors identified comparable gains in both blended and non-blended environments (Bishop 2010; Preusser, Bartels, and Nordstrom 2011; Hrubik-Vulanovic 2013). Preusser et al. (2011) report neutral impacts for an online sexual harassment awareness training course delivered in the workplace. Employees were randomly assigned to participate in either a self-paced individual CD-ROM based course or a blended version consisting of live instruction and video-clips and PowerPoint slides from the CD-ROM There were no significant differences between the groups in their satisfaction with their learning experience, gains in knowledge of relevant vocabulary, beliefs about sexual harassment, and gains in skills for identifying or addressing sexual harassment.

Bishop (2010) and Hrubik-Vulanovic (2013) both studied the effectiveness of TBL interventions delivered in an "emporium-style" course for developmental and remedial math education.[37] In both cases, students from the TBL environment completed modular online assignments with immediate feedback for the student and on-demand access to assistance from instructors. Bishop (2010) reports that this style of blended education yields neutral learning impacts in a developmental math course.[38][39] Hrubik-Vulanovic (2013) reports that students who complete such a course may succeed in their subsequent introductory math courses, performing comparably to their peers who did not need remediation.

---

36 These cases serve as a reminder that, while learners in TBL environments have been shown to perform equally as well as those in traditional classroom environments, this finding can sometimes be attributable to poor performance among learners in both groups.

37 According to the National Center for Academic Transformation, the emporium course model replaces lectures with a learning resource center model featuring interactive computer software and on-demand individualized assistance (http://www.thencat.org/PlanRes/R2R_Model_Emp.htm). This particular approach to blended learning substitutes certain aspects of the traditional face-to-face course for TBL resources, a concept discussed in more detail below.

38 The author included students from six courses in her sample. Three of these courses were considered college-level and thus out of the scope of this review. The other three were considered developmental and thus in-scope. Since roughly half of the sample was relevant, we chose to include the paper's results in our review, noting it with caution.

39 Notably, while Bishop reported no significant learning impacts, she did identify significantly more positive attitudinal outcomes (increased self-confidence, motivation, and value and enjoyment of math) among the traditionally-educated comparison group. These attitudinal findings mirror the generally mixed evidence for attitudinal outcomes discussed above.

Training for the health professions has historically been a significant focus of the workforce development system thus underscoring the importance of several studies that have examined the effectiveness of TBL in support of a nursing degree. With their inherent emphasis on clinical experience, nursing programs may more naturally translate to blended interventions, combining asynchronous, online coursework with clinical instruction. In the most extensive evaluation identified to date, Kummerow et al. (2012) found that an online sophomore-level mental health course yielded comparable content mastery to the traditional classroom-based offering. Nursing students who chose to take the course online earned comparable scores on the Assessment Technologies Institute Registered Nurse (ATI RN) Mental Health test as those who were taught in the classroom and who had comparable grade point averages and academic skills.

Other interventions that move learners between technology and traditional classroom environments also appear to yield positive impacts on workforce-related outcomes. For example, among a sample of learners training to become naval avionics technicians, Parchman (2000) replaced a portion of the classroom course with three different types of TBL strategies: computer-based drill and practice, computer-based multi-media drill and practice, and a game-based virtual world. Each took place in a classroom setting that allowed for interaction with peers and classroom instructors. After randomly assigning learners to each strategy, the researcher analyzed four different post-program measures of content knowledge and found that learners in the two computer-based environments, both of which used a drill and practice approach to instruction, outperformed their peers in traditional classroom instruction along two measures (and did not differ along the other measures).[40] In both cases of using computer-based drill and practice, the TBL learners correctly answered as much as 30 percent more post-test questions correctly than did learners in the traditional instructional settings. Additionally, learners in the drill and practice TBL classes took less time to complete course requirements. Finally, in contrast to the findings for technology-only interventions, the authors reported no significant differences in learner satisfaction between the traditional and three blended instruction strategies. Again, these findings may not generalize to the current context since the technology being tested is older.

Some of the largest positive outcomes from a TBL course relative to a comparison group have been reported in assessments of the Digital Tutor (DT) developed by Defense Advanced Research Projects Agenda (DARPA) (Fletcher and Morrison 2012).[41] The Digital Tutor is an artificial intelligence platform designed to replicate the behaviors of exceptional human tutors. In its application in support of information technology training, DT instruction is supplemented with instructor-led study halls. Trainees in DT programs have substantially outperformed comparison groups on tests of content knowledge and

---

40 The four measures were all subtests from the Navy Personnel Research and Development Center (NPRDC) test. They included knowledge of definitions, knowledge of symbols, qualitative knowledge, and quantitative knowledge.

41 In these reports, researchers typically compare the content knowledge and performance of DT participants, all of whom are trained as entry-level Naval IT technicians, to participants from a separate computer-based IT course and to incumbent workers with many years of on-the-job experience. Notably, these comparison groups may differ from DT participants in ways that could affect the results and necessitate cautious interpretation of the results. For instance, incumbent workers with many years of experience could underperform on tests of general content knowledge to the extent that these workers lose some familiarity with course material over time and their work experience encourages the development of specialized skills at the expense of broader content knowledge.

their ability to solve and complete practical, hands-on troubleshooting problems. The comparison groups included students who were graduates of more traditional (but comparable) IT courses as well as incumbent workers whose job requires the mastery and application of these key competencies.

These findings for the impacts of blended learning for job trainees are consistent with older findings in ABE programs as well. Li (2005) compared the math achievement of learners in two adult basic education programs, one that supplemented class instruction with computer-lab time on a teacher-created Website and one that consisted of class-time alone. While there were no significant differences on final grades in the class between groups, the TBL group outperformed the traditional classroom learners on three of six unit tests and equaled their performance on the remaining tests. Likewise, Nicol and Anderson (2000) compared the impacts on workforce-related learning for ABE students with mild learning disabilities. Those randomly assigned to a traditional class supplemented by a one-hour self-paced and instructor-assisted computer course had significantly higher numeracy scores than did those with no instruction.

Finally, there is some older evidence that blended interventions may be best suited for certain populations. McKane (1996) tested how the impact of blended learning differed with pre-program education levels. In this instance, the tested intervention was meant to improve the way adults "automate" their lower-level literacy skills. The authors found that the blended intervention had the largest and only significant positive impact among the low-level literacy learners with the lowest pre-program education, identified as less than a 4th grade equivalency level. Among the low-level literacy learners with higher education levels, the authors found no significant differences between the blended and the traditional classroom groups. However, the authors caution that there was high attrition and non-compliance in the randomized control trial, meaning that a high number of individuals assigned to receive the intervention may not have done so and that a high number of those assigned to the control group may have received the intervention.[42] It also should be noted that the findings are from more than a decade ago and caution should be used in generalizing the findings.

5.2.1 Design Features of Promising Synchronous, Blended Interventions

Typically, the blending of traditional and technology-based learning is achieved by introducing technology into the pre-existing traditional classroom. In this way, a common design element of the blended learning environment is the extent to which the technology is introduced as a substitute for traditional learning or an addition to traditional learning (Swars, Stinson, and Lemons-Smith 2009). The distinction has to do with the total quantity of instructional content available to the learner. When technologies are introduced to serve as a substitute for traditional instruction, one might argue that the two designs offer comparable exposure to the course content. When introduced as an addition to the existing environment, the technology increases the total learning content relative to the traditional, non-blended learning environment.

Perhaps unsurprisingly, blended learning impacts are largely positive when technology is introduced as an additive component (Burgess 2010; Rohlman et al. 2004; Lin 2013). For example, Wladis (2014) evaluated the impact of supplementary online instruction on the rates at which students complete and pass

42 The noncompliance cited by the authors included refusals to complete post-tests or the intentional manipulation of performance on post-tests on the part of study participants.

a development math course. When struggling students—identified by their mid-term grades—were tasked with completing additional online course material, course pass rates significantly improved. As discussed earlier, Li and Edmonds (2005) report neutral or positive learning impacts when supplementing classroom instruction with technology-based learning. This suggestive evidence is bolstered by findings from more rigorous studies of blended TBL as an addition to instruction. Supplementing a developmental reading course with exercises completed in *Second Life* perhaps unsurprisingly improves reading achievement (Burgess 2010). In Rohlman's 2004 study, all learners worked in a computer-based environment, but in a treatment group, learners were given the opportunity to also use hard-copy, text-based course content as a reference when completing a course examination. Those in the blended group demonstrated significantly more knowledge of respiratory protection, and the impact persisted for at least one month after the intervention. Lin (2013) reported positive impacts from the introduction of an inter-personal, collaborative discussion board into an otherwise independent TBL environment. In these cases, the mode of learning is confounded by the additional learning content.

When TBL is used as a substitution for traditional learning, the findings are less uniformly positive. In these cases, the amount of learning content is controlled for and only the mode of delivery changes. Blended learning as a substitute is at least as effective as, if not more effective than, traditional learning. In some studies (e.g., Batchelder 2000; MANILA 2008; Kummerow 2012; Bishop 2010; Hubrik-Vulanovic 2013), there are no significant differences between blended TBL and traditional instruction, holding content constant. In others, blended learning is more effective than traditional learning, even when TBL is a substitute for traditional learning (e.g., Fletcher 2012; Nicol 2000; Wladis 2014).

Moving beyond the substitution/addition dichotomy, several studies tested interventions structured to cycle learners between strictly technology-based learning and strictly traditional learning (Exhibit 9). For example, Parchman's (2000) treatment simply removed learners from a traditional classroom-based course to complete a portion of the course in a computer-based environment before returning to the classroom. Likewise, Job Corps learners in the READ 180 program would split their day between periods of time spent working independently on a computer, working in groups with peers, and participating in traditional teacher-led classroom instruction (MANILA Consulting Group Inc. 2008). Inmates in Batchelder's (2000) study would alternate between traditional classroom education and self-paced work in a computer lab. In other studies, there were other approaches to blending technology and traditional instruction. For example, in Rohlman et al.'s (2004) treatment group learners were given the opportunity to also use both computer-based and hard-copy, text-based course content simultaneously.

Exhibit 9: Rigorous Studies of Design Features of Blended Interventions

Study	Intervention Summary	TBL	Impacts
Lin, 2013 RCT	Catheterization instruction for junior college nursing students in Taiwan	Contrast: Blended (addition) with cooperative discussion of content via discussion boards (v. blended with no discussion boards) In both cases: Blended Asynchronous Content centric	+learning impact
Preusser, 2011 RCT	Sexual harassment knowledge and soft skills training at the workplace	Contrast: Blended (substitution) (v. technology-only) In both cases: Synchronous Content-centric No interaction via tech	NS learning NS satisfaction rating
Rohlman, 2004 Study 3 RCT	Respiratory protection knowledge for adults	Contrast: Blended (addition) with referrals to traditional materials during quizzes (v. technology-only) In both cases: Synchronous Content-centric No interaction via tech	+ learning

Notes:
In Column 1: RCT indicates that the study used a randomized control trial design; QED indicates that the study used a quasi-experimental design.
In Column 4: "+" indicates a positive significant impact; "NS" indicates no significant impact; "-" indicates a negative significant impact.
Rohlman 2004 also tested technology-only (see Exhibit 6, Exhibit 7)

One component that may be of particular interest to designers of blended TBL interventions is the extent to which technology-based or traditional environments are each emphasized in the blending of the two. Thinking of a course in its entirety, designers may want to consider the ramifications of choosing to blend TBL into only a portion of the course, roughly half of the course, or nearly all of it. While the research cited above does not test this design feature explicitly, the assessments of DARPA's Digital Tutor shed some interesting light on this topic. Researchers administered multiple assessments of the effectiveness of the DT as it was being developed and as it was slowly phased into the traditional human tutoring environment (Fletcher and Morrison 2012). In one early assessment, trainees completed four weeks of the computerized DT training before finishing the rest of the course material using traditional face-to-face instruction. In a subsequent assessment, trainees completed seven weeks of the DT program before transitioning into traditional instruction for the remainder of the course. Finally, in the most recent assessment, trainees completed the full 16-week DT program without traditional instruction. Comparing the results of these three assessments, the authors consistently report substantial, large positive impacts of the DT program on tests of content knowledge. In this instance, it appears that the benefits of a technology-based intervention can be realized at varying levels of "blendedness" with traditional education.

5.3 Summary

While the impacts of these TBL strategies are varied, several trends emerge from the empirical literature. First, forms of TBL that promote more interaction are likely to be as effective, or more effective, than traditional interventions for improving workforce-related outcomes.

- Asynchronous, technology-only interventions (like standard online classes), which have the least potential for live interactivity, vary from having negative to positive impacts on measures of workforce-related outcomes, including satisfaction, knowledge, and implementation of skills .
- Synchronous, technology-only interventions (like streaming webinars or discussion groups), which have greater potential for interactivity, are more likely to be as effective as traditional interventions in affecting workforce-related learning (however, they are associated with some negative impacts on satisfaction, motivation, and attitude).
- Finally, blended interventions, which almost necessarily include interaction during the "traditional" components, are likely to be as effective as traditional interventions in affecting workforce-related learning. Most are also likely to be as effective in affecting other workforce-related outcomes.

Additionally, the evidence suggests that technology-only interventions may be more effective if they include active engagement with and learner control over content and practice work with feedback.

6. Recent and Emerging Trends in TBL

The previous chapters have documented many of the conceptual and empirically demonstrated strengths of TBL, as well as a variety of factors that potentially shape its use. The net result has been a growth in the adoption of use of TBL in support of workforce development objectives and for workforce training and education (Roy and Raymond 2008; Maxwell 2012; Maxwell et al. 2013; Allen and Seaman 2011; Allen and Seaman 2013; Betts, Cohen, et al. 2013; Carruth and Carruth 2013; Hart 2012; Rossett and Marshall 2010; Marshall and Rossett 2011; Teplechuk 2013). Alongside this growth in use and demonstrated effectiveness is the unabated emergence of new technologies, such as mobile applications and virtual worlds. These technologies continue to be leveraged for pedagogy and will continue to fuel demand for TBL. The research suggests that, in addition to capitalizing on the emergence of new platforms and applications, TBL is evolving a cross-cutting emphasis on enhancing the capacity and flexibility of current and emerging technologies to achieve a number of critical instructional objectives (e.g., Barrett 2012; Gungor and Prins 2011; Hairston and Nafukho 2011; Wang and Lockee 2010; Hignite, Katz, and Yanosky 2010; Boja, Pocatilu, and Toma 2013). These critical instructional objectives are listed below:

- Improving access to and scalability of learning, ultimately saving costs and resources
- Individualizing learning to better adapt to learner needs
- Promoting explorative and active learning to allow for more learner engagement
- Facilitating social learning through enhanced tools and processes for interpersonal interaction
- Utilizing data to monitor, assess, and signal learning

While the discussion in this chapter is organized around these cross-cutting priorities and themes, it is important to remember that many innovations capitalize on TBL's strengths across multiple dimensions. For example, virtual worlds, which are discussed in terms of their capacity to advance social learning, may also represent an opportunity to strengthen individual learner engagement.

In reviewing these trends and priorities we cite empirical evidence of effectiveness where it is available. Because these innovations are new, there has been less time for the field to generate rigorous evidence on their effectiveness. In many instances, the available evidence is preliminary or stems from less rigorous types of evaluation than the studies highlighted in Chapter 5. Nonetheless, the research provides valuable operational and design insights as well as useful direction for future investments in TBL interventions and research.

6.1 Improving Access To and Scalability of Learning

Earlier chapters in this document have noted that one of the major considerations in the adoption of a TBL strategy is the significant fixed costs associated with content development and establishing the technological infrastructure (Bowen and Ithaka 2012; Maxwell 2012; Roy 2010; Gan et al. 2013; McKay and Izard 2012). However, once the technological infrastructure is established and instructors and learners are familiar with the tools and effective TBL instructional methods, a significant strength of TBL is its scalability or the relatively low marginal cost of delivery (Bowen and Ithaka 2012; U.S. Department of Labor 2008a). The prevalence of mobile and Internet-capable technologies has exploded over the past decade, enabling relatively low-cost access to learning content for previously unreached populations

(Maxwell 2012; Carruth and Carruth 2013; Koller, Harvey, and Magnotta 2006). Two particularly notable emerging trends in TBL that may improve the access to and scalability of learning are the increasing availability of learning via mobile technologies and the growing availability of Open Educational Resources.

According to the Pew Research Center's Internet Project research, today 90 percent of American adults have a cell phone, up from 68 percent in 2004. Mobile technology usage is ubiquitous and thus democratic: 84 percent of adults with household incomes less than $30,000 have a cell phone and 47 percent have a smart phone (Pew Research Center 2014). Along with this persistent growth in mobile usage, there has been a similar evolution in the types of mobile technologies available today. In addition to a vast array of cell phones and smartphones based on closed and open-source operating systems, the use of tablets has grown from 3 percent in 2011 to 42 percent in 2014. Accompanying this explosion of mobile technology, and the use of it for learning, there has been an increase in the amount of research interest in mobile learning over the last decade, although the major populations of interest have been higher education and elementary students (Hsu et al. 2012; Hwang and Tsai 2011).

Mobile devices have several key advantages for learning.

- First, mobile devices enable speedy anytime-anywhere *interaction*. Via phone calls, text messages, and, with smart phones, emails, video chatting, and other messaging apps, synchronous and asynchronous interaction and collaboration is made possible.
- Second, the Internet access afforded by most mobile devices today enables anytime-anywhere *access* to learning content. This includes static text, audio, and visual content from free and otherwise Web-based resources. It also includes entire learning programs and applications. In other words, mobile learning makes previously non-mobile technology available via mobile applications. For example, there is now a mobile version of Rosetta Stone's electronic language learning curriculum.
- Third, mobile devices allow for content to be delivered in a more *flexible, modularized fashion*. For example, if students can access interactive practice exercises on a mobile device, they can more effectively use short periods of time while commuting, during meal breaks at work, and so on (Russell, Lippincott, and Getman 2013). Lectures can be recorded and downloaded to podcasts, which the students can listen to on their mobile devices at a more convenient time.
- Finally, the advent, development, and growing use of mobile technologies, coupled with learning applications, widespread Internet access, and availability of open educational resources (OERs) has increased opportunities for flexible anytime-anywhere learning at a *low marginal cost* (Pimmer, Pachler, and Attwell 2010).[43]

Unsurprisingly, then, mobile technologies are beginning to be used or have the potential to be used in a variety of learning contexts, including language learning and adult education (Yang 2013; Godwin-Jones 2011; Russell, Lippincott, and Getman 2013; Warschauer and Liaw 2010). Mobile devices can also be used to support many of the trends highlighted in this chapter, for example, educational games; social

[43] While there are no formal published cost studies, some researchers suggest caution in the use of handheld devices for adult education due to the devices' higher cost-benefit ratios as compared with full function low-cost computers and laptops (Warschauer and Liaw 2010).

media utilization, e.g. audio blogs for vocabulary learning; learning analytics; immersive and augmented reality; and, potentially, adaptive automated tutoring (e.g., White House 2014a; Yang 2013; Aljohani and Davis 2012; Liu, Gomez, and Yen 2009; Ghadirli and Rastgarpour 2013). Each of these technologies is discussed in detail below.

Open Educational Resources (OERs) represent another way TBL is scalable through its ability to easily and efficiently reproduce, update, and streamline educational resources over the Internet (Koller, Harvey, and Magnotta 2006). OERs are "teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits sharing, accessing, repurposing—including for commercial purposes—and collaborating with others" (U.S. Department of Education 2010). In other words, OERs are publically available instructional and learning materials that may be used by anyone with Internet access. Additionally, many of these resources can be customized to fit learner and instructor needs (Godwin-Jones 2011). OERs range widely and can include limited, focused content found in static articles (e.g. on Wikipedia or Digital Commons) and explanatory videos (e.g. YouTube), or may be more comprehensive curricula, courses or programs like MOOCs and full course management systems (e.g. using BlackBoard and Moodle). Ultimately, OERs may minimize or even eliminate the development costs of TBL. Then, by using online distribution technologies, OERs enable educators and trainers to reach large populations at low marginal costs (Russell, Lippincott, and Getman 2013; Teplechuk 2013; Carruth and Carruth 2013).

A number of national and local initiatives are under way to raise awareness and support for making educational resources freely available and usable (Mullins 2013; Bai and Smith 2010; Godwin-Jones 2011). For instance, in some of its recent grants (e.g., TAACCCT and the Ready to Work Partnership Grants), DOL has required that electronic curricula and materials developed or modified for the grants be made available for public use under Creative Commons Attribution 4.0 (CC BY) license. Beyond funding the development of OERs, there are also national initiatives to collect OERs in centralized repositories. For example, the Administration's Digital Literacy portal links to a variety of free resources that not only address digital literacy but also other workforce-related needs such as basic skills and job search, application, and preparation processes. As described in Chapter 4, the Online Skills Academy, which DOL will launch in 2015 through a competitive $25 million grant, will provide high-quality, free or low-cost pathways to degrees, certificates, and other employer-recognized credentials (White House 2014a). This Academy, in turn, draws from the resources of the OER Repository Microsite, which ETA will create to house hundreds of digital instruction products including lesson plans, professional development materials, courses and course modules, institutional research, and evaluation tools. These products incorporate online and/or technology-enabled learning strategies, such as interactive simulations, individualized and virtual instruction, educational gaming, digital tutors, asynchronous and real-time collaboration strategies, and next generation assessments (White House 2014b).

At present, data on the effectiveness of OERs is quite limited. Despite their increasing availability and considerable potential, in 2012 64 percent of community colleges surveyed by the ITC anticipated OERs would generate very little to no impact in the next three years (Mullins 2013). Further, respondents attributed this expectation to difficulties locating and evaluating OERs, concerns over their credibility, and a lack of faculty awareness. This finding suggests that expectations for OERs may change as they and the repositories become more prevalent or visible as well as evaluable and digestible. In fact, the share of colleges anticipating little to no impact of OERs dipped slightly to 50 percent by 2013, but colleges continued to report difficulties and concerns at the same rates (Lokken and Mullins 2014)

6.2 Individualization Through New Instructional Approaches and Data Analytics

Given the importance of differentiating instruction to specific needs of individual learners, other instructional approaches and technologies are being used in learning and training to address this issue directly. This trend builds on both the use of technology to improve the access and scalability of learning and the use of technology to use data. The opportunity for more individualized learning is being recognized and seized through the restructuring of content delivery and instructional approaches, as well as the use of educational data for adaptive instruction.[44]

Another instructional approach enabled by the use of technology is competency-based education and training, which teaches individual skills or learning outcomes, one at a time. Emerging uses of technology, like the **U-Pace instructional method**, organize and track competency development so that instruction can be customized to the individual learner. Specifically, the U-Pace instructional method organizes material for introductory courses into small segments and requires that students pass an online quiz about that material in order to advance to the next section (Reddy, Fleming, and Pedrick 2012). An LMS allows instructors to monitor student behavior (e.g., number of quiz attempts). In this way, the time that would have been spent delivering instruction in a classroom is freed up to motivate students and support their learning (ibid). Generally, a competency-based approach may be able to achieve greater relevance to labor market needs and improved quality (U.S. Department of Education 2014). Additionally, because many competency-based education and training programs allow students to self-pace, they also increase the accessibility and affordability of learning (ibid).

While the above section discussed the use of data to support instructors actively customizing course content, technology also allows automatic use of data to support individualized learning experiences and allow for differentiated instruction. **Adaptive learning systems** are being used as fully online courses, as supplements for online courses, or within blended learning contexts (Oxman and Wong 2014).

Minimally adaptive learning systems, sometimes referred to simply as Computer-Assisted Learning or Computer-Aided Instruction, offer individualized pacing and may provide feedback on learners' answers to built-in assessments (VanLehn 2011). In these courses, content is typically presented to all learners in the same way, but with small adaptations intended to target content to students. For example, Vassiliou (2011) studied the use of a Computer-Aided Instruction program by community college learners in remedial classes. The program, A+dvancer College Readiness Online, included a baseline assessment of learners' knowledge that identified deficits and prescribed individualized lessons to address these deficits. After participating in the program, learners demonstrated significant improvements in sentence skills, reading, elementary algebra, and arithmetic.

However, not all forms of adaptation, especially those considered minimal, have demonstrated impact. Some evidence suggests that minimally adaptive learning systems that provide generic feedback do not improve learning outcomes in an online course. Kasitz (2013) created five generic efficacy-enhancing messages that were sent weekly via email to at-risk high school students. The chosen templates for each

44 According to the National Education Technology Plan (U.S. Department of Education 2010), individualization refers to instruction that is paced to learning needs, tailored to learning preferences, and tailored to the specific interests of different learners. In an environment that is fully individualized, the learning objectives and content as well as the method and pace may all vary.

student varied based on the student's ongoing performance, but there was little additional individualization beyond the inclusion of the learner's name. Results showed insignificant impacts on learning and self-efficacy among learners in online courses that did and did not incorporate this particular feedback.

More sophisticated adaptive software programs include **Intelligent Tutoring Systems**, such as the Digital Tutor developed by the DARPA. These systems use cloud computing technologies and techniques for managing large amounts of real-time data that are then assessed by the programs to provide feedback and adapt instruction to the learner's needs and characteristics (West 2012; Oxman and Wong 2014; U.S. Department of Education 2013). For example, an adaptive math program may intersperse lessons with drills, and learner performance on those drills dictates the content of subsequent lessons. With more sophisticated software, users receive feedback and hints at each step of the problem-solving process, creating a more human-like tutoring experience (VanLehn 2011). For example, AutoTutor is a sophisticated adaptive software system that also tracks emotions via dialogue patterns, facial expressions, and body posture. Developed by researchers at the Institute for Intelligent Systems at the University of Memphis, Auto Tutor instructs adults in, among other topics, computer literacy. It uses a five-step human-like dialogue process: (1) the AutoTutor asks a main question (e.g. "When you turn on the computer, how is the operating system first activated and loaded into RAM?"); (2) the student gives the initial answer through either written or spoken natural dialogue (e.g. "When the computer is turned on a file is automatically booted up"; (3) the AutoTutor gives short feedback on the quality of the student's answer in #2 (e.g., "ok," "alright," "anything else?"); (4) the AutoTutor and student collaboratively interact with feedback and hints from the tutor (e.g., "What about storage?"); and (5) the AutoTutor gives positive feedback, summarizes, and verifies that the student understands (e.g., "Right. The CPU executes instructions in ROM, which helps the operating system to start. Do you understand?") (D'Mello, Dowell, and Graesser 2011). Additionally, some groundbreaking work is also being done at the University of Massachusetts to build adaptive learning systems that use a camera, posture sensing devices, skin conductance wristband, and pressure sensitive mouse to respond to emotional states and motivation levels (Office of Educational Technology 2013).

ALEKS (Assessment and Learning in Knowledge Spaces) is another example of a Web-based Intelligent Tutoring System used in some developmental math courses to individually and continuously assess students, while allowing for customization of the content (Hrubik-Vulanovic 2013; Taylor 2006). ALEKS is based on the theoretical framework of knowledge spaces, in which particular elements of knowledge (concepts in Algebra, for example) can be combined to form distinct knowledge states of individuals. This framework enables the creation of computer algorithms for constructing and applying discipline-specific knowledge structures (known as "Knowledge Spaces"). For example, after receiving an interactive tutorial on ALEKS software usage, a learner takes an initial free-response assessment, based on the syllabus or standards set by the instructor and consisting of 20-30 questions that may need to be solved on paper or directly in the online environment. ALEKS uses this data to determine the learner's current knowledge state and what she is ready to learn next, which is then depicted in a color-keyed pie chart report. In the learning mode, ALEKS provides open-response practice topics, explanations, input tools, and resources. It then analyzes student input and offers advice and feedback. Instructors can view individual student assessment results, progress in the learning mode, and total time spent in the system.

A final feature of newer adaptive software is that they allow for *instructor*-customization. While adaptive learning systems have tended to use a publisher model, where course content is built into the product, newer platform models provide authoring tools that enable individual faculty or curriculum teams to create and customize their own products (Oxman and Wong 2014).

As these adaptive systems continue to develop, researchers are just beginning to rigorously study their effectiveness and generate insights into best practices to feed back into the field. This existing evidence base for the Digital Tutor was discussed in Chapter 5's review of impact evaluations. In Hrubik-Vulanovic's (2013) application, ALEKS also offered immediate feedback as learners worked through practice problems. Feedback included step-by-step solutions and individualized summative feedback reporting on the learner's progress and performance. As discussed in Chapter 5, Hrubik-Vulanovic found no significant differences when comparing performance in a college-level math course for students who had previously completed a remedial ALEKS courses and those without previous ALEKS experience (ibid).

Finally, Hrubik-Vulanovic (2013) identified two important limitations of these intelligent tutors: large costs associated with their development and maintenance and inability to share information and knowledge about learners across systems. However, the continuous improvements in technology along with increases in OERs are already helping to lower costs, and standards being developed by IMS Global Learning Consortium Inc. (Instructional Management Systems Global Learning Consortium Inc.), the IEEE LTSC (Institute of Electrical and Electronics Engineers Inc. Learning Technology Standards Committee) and the ISO/IEC (International Standards Organization/International Electrotechnical Commission) are helping to improve interoperability (ibid).

6.3 Individual Engagement Through Entertainment and Active, Exploratory Learning

The individualization of learning by definition has the potential to create a more engaging learning process. However, the connection between engagement and individualization works in both directions. Emerging technologies like educational games and simulations have an engaging, often non-linear or self-directed exploratory learning format that is, in essence, individualized. By having learners play a more active role in their learning, these technologies directly engage and empower learners. On an individual level, two trends contributing to the broader aim of learner engagement are the use of games and immersive simulations.

Game-based learning (i.e., gamification) in education and training is the use of game-based mechanics, aesthetics, and game thinking to engage people, motivate action, promote learning, and solve problems (Kapp 2012; Apostol, Zaharescu, and Alexe 2013). Although educational games are not necessarily technology-based, technological games have many of the benefits and features of technology already discussed. For example, mobile game-based learning has the flexibility and comfort afforded by personal mobile devices (Deniozou 2013). Gaming software, by recording outcomes and actions, can facilitate assessment of progress by both the instructor and learner/player (Abrams and Gerber 2013). The fact that the newest generation of workers has grown up with computer games, game-based learning holds particular appeal and potential for adult learners and the workforce population (Uram, Wilcox, and Thall 2010).

Common elements of game-based learning include rules and story to set and structure the learning context; attainable goals and challenges to focus the learner and enhance self-esteem; the freedom to fail; feedback to support engagement; and user control and ability to affect the outcome (Apostol et al 2013;

Kapp 2012; Uram 2010). Games embody a range of techniques that help create effective learning experiences and ways of stimulating engagement in a safe and motivational way (Whitton 2012) Incorporated into other types of education and training, these features can show instructional designers how to make instruction more engaging.

Often called "serious" games since their purpose is not entertainment, these emerging technology applications are making their way into a variety of contexts for workforce training and education. Employers such as Cold Stone Creamery, Cisco Systems, and the U.S. Navy have adopted computer games for training (Huang et al. 2010). Multi-player games like "Everquest" are being used in adult ESL instruction (Warschauer and Liaw 2010). Additionally, other game-based learning experiences are being designed specifically for workforce development. For example, Star Gaze uses a series of game-based "missions" to build occupation-specific English Language listening and reading skills (http://skylablearning.com/; https://www.edsurge.com/skylab-learning). One mission is Launch Sequence, which supports general and industry-specific conversation skills such as greetings, people and objects, food and menus, and directions. Leaners tap one in a set of connected hexagons to listen for a word. They then choose the text or symbol associated with that word from scrolling lists. A correct answer results in the hexagon lighting up; when three connected hexagons are lit up, an image is uncovered. Scores can be compared with other learners through the leader board.

There is no empirical research about which elements of games are most appropriate for workforce development and education. Theory holds that the key to designing instructional games is incorporating the less costly and enjoyable elements of games while still using learner participation to further both engagement and learning (Hodara 2011). Some elements, such as rewarding users with score points and badges, offer entertainment value but may provide only extrinsic motivation, triggering a superficial level of engagement (Kapp 2012). Others, such as user control of content, pathways, or strategies, can trigger more intrinsic motivation while individualizing the learning process (Apostol 2013).

Like games, **e-Learning simulations** provide an engaging learning environment. Unlike most games however, simulations are less structured and not necessarily competitive. They engage learners not through a story but by providing a realistic and exploratory environment. In this way, these emerging technologies provide an experience-based, self-directed learning experience, which aligns with adult learning theory (Merriam 2001; Hetzner et al. 2011). Further, because this experiential learning is simulated, it can potentially be undertaken asynchronously thus making accommodations for the time and locational constraints of learners in workforce training and education.

Used in medical education and in the workplace for vocational skills training, these simulation technologies can replicate a realistic workplace environment and provide practice-based learning (Mancuso, Chlup, and McWhorter 2010; Connor 2012). One example is the e-HIM Virtual Laboratory (Virtual Lab) implemented by the Medical College of Georgia and Macon State college. As of 2009, it was in use in over 80 community colleges and 251 health information programs in the United States (Barefield et al. 2010). Virtual Lab provides a platform from which students can get hands-on training in a variety of Health Information Administration applications, anytime and anywhere.

Research shows that "realistic" training can yield better results for training participants (U.S. President 2014b). One case study considered self-reported accounts from incumbent registered nurses looking to transition into more advanced nurse practitioner positions (Hurst and Marks-Maran 2011). Based on their experiences, learning with a virtual patient—a text-based simulation whereby students solicited patient history and choose from different diagnoses—was reported to have effectively helped learners develop their confidence as well as skills for patient assessment, decision-making, and prescription writing.

However, e-learning simulations are not without limitations. One major barrier to their use and implementation are the costs and challenges educators and businesses face creating the environments. As the cost of computers and graphic systems have decreased, so may the cost of these simulations. Another limitation is that immersive simulations tend to be disconnected to the real-world knowledge and experience of individual learners, though they are customized to the learning content (Hetzner 2011; International Innovation 2013). “Simulations typically reflect a snapshot of time and training needs; it is also time consuming to adapt the content and interaction to frequently changing work contexts and learning needs” (International Innovation 2013).

Addressing this gap between the real and virtual world, an international group of researchers has adopted an augmented simulated experiential learning approach through the ImREAL (Immersive Reflective Experience-Based Adaptive Learning) project (International Innovation 2013). Mainly targeting the training sector, especially medical practitioner training, the project aims to customize simulated environments by sensing the relevant learner experiences in social media using social science models, ontologies, and digital trace analyses, and by opening up the simulator-development environment to external content.

6.4 Facilitating Social Learning

Social media is not only a tool for individualizing learning but also for socializing it. Especially for adult learners, peer-to-peer and instructor-learner interaction is critical (Abrami et al. 2011; Bernard et al. 2009; Dunham et al. 2011; Sher 2009; Woods Jr. and Baker 2004). Initially, TBL relied almost exclusively on asynchronous discussion boards and chat software to allow for interaction between learners and instructors in an e-learning environment. These strategies continue to be a staple of many TBL courses today, and research demonstrates that learning outcomes improve with increased participation (Hsu 2014). Accordingly, the field continues to refine its understanding of these particular collaborative social learning strategies. Offenholley (2012) analyzed conversations conducted over discussion boards associated with online mathematics classes at selected for-profit and community colleges. Based on their coding of the discourse and correlational analyses, findings suggest that instructors can promote participation from learners through more evaluative, almost Socratic, posts of their own. Instructors also can both overwhelm a conversation, stifling student participation with too much of their own activity, and fail to stimulate conversation with insufficient participation (Offenholley 2012).

This section focuses on more recent trends in social learning, and the technological tools and processes that are driving adult learning toward more collaboration, active learning, and engagement: flipped classrooms, Web 2.0, and virtual worlds.

The “**flipped classroom**” is an example of the use of technology to invert the traditional learning environment and promote interaction (Lemmer 2013; Hamdan et al. 2013). This blended approach combines learners asynchronously consuming lecture material at home and at their own pace and using in-class time for learners to debate issues, explore topics in greater depth, solve problems with peers, and carry out collaborative, meaningful analytical and critical thinking activities (Gallagher and Garrett 2013). Thus, what used to be classwork (e.g., the "lecture") is done at home via teacher-created videos, OERs, or other static content (Smith and McDonald 2013). What used to be homework (e.g., problem-solving and analysis) is now done interactively in the classroom and guided by an instructor. While the flipped classroom and traditional classroom models share the expectation that learners will prepare for class, the flipped classroom ensures that all the learners are engaged with the material during class time. Additionally, flipped classroom instructors can link to and customize existing freely available resources (e.g. OERs) or create materials tailored to their learners. In the context of professional development, some initial data indicate that trainees—in this case, in-service K-12 teachers—may prefer a flipped instructional design over more traditional professional development courses (Spencer 2012). The author asked a convenience sample of teachers to self-report their experience in previous professional development courses as well as in a flipped course. Comparing these reports, learners' experience was far more positive in the flipped professional development model developed for the study. The model included multiples phases, first allowing learners to explore the new technology through classroom examples or live demonstrations, then completing tutorials or other resources available online, and, finally, a phase that emphasized learning-by-doing and applied knowledge.

Web 2.0 is the second generation of Web development and design aimed at facilitating learners' collaboration, content generation, and information sharing (London and Hall 2011). The technology consists of applications called **social media technologies** that support learner-learner, learner-instructor, and learner-content interactions (e.g., Wiki, Twitter, and Google Docs, podcasts, virtual worlds). For example, learners might be given assignments to use technologies to produce materials that are important to their work and family lives—posting videos and photos, creating blogs, contributing to wikis, or participating in a Facebook group. These materials can then be reviewed by peers and instructors, who can provide feedback through comments (Hsu 2008).

The explosion in social media has accelerated the level of interest in learner-centered education and training in a team environment (Godwin-Jones 2011; London and Hall 2011, 2011; Martinez-Aceituno et al. 2010; Pop 2010; McKay and Izard 2012; LeNoue, Hall, and Eighmy 2011; Diaz 2010). Contributing to such online projects could engage and motivate students in their learning (Russell, Lippincott, and Getman 2013). Social media tools are also well-suited for engaging students who may be less demonstrative and outspoken in a group setting, as perceptions of anonymity may make participation in an online format easier (Heindel 2014; Levine, Winkler, and Petersen 2010). Finally, Web 2.0 tools can be used to create learning communities within TBL courses, which can help overcome learners' feelings of disengagement with online courses (Angelino, Williams, and Natvig 2007; Moody 2004).

As a result, Web 2.0 is making its way into many learning and training contexts. For example, some corporations are using Wikis for collaborative generation and sharing of company documentation (Martinez-Aceituno et al. 2010; McKay and Izard 2012).Shell's Wiki is updated and maintained by employees all across the world, with entries ranging from training materials and technical handbooks to information on a wide variety of subjects, forming a web of interconnected knowledge (Hendrix and Johannsen 2008). Additionally, recent reviews from the field suggest that Web 2.0 and social media sites can enhance career development, not just by making information more available but also by helping learners build professional contacts (e.g., LinkedIn) and social relationships (e.g., Facebook) within a course (Diaz 2010; Burgess 2009; Walsh et al. 2011).

Initial feedback from both learners and instructors suggests that these technologies can innovatively meet their needs. Hsu (2008) studied the use of social learning within an adult ESL course. Students were assigned to record their responses to language assignments using their cell phones and to upload those recordings to an audio-blog. An instructor was able to record customized feedback for each student and leave written comments on the blog. In self-report surveys, students and the instructor reported that the blog was an accessible language-learning tool that facilitated constructive interaction with their professor.

Web 2.0 tools are not without their challenges, though. Privacy and intellectual property, which are difficult to control in an open environment, remain ongoing issues for the successful implementation of Web 2.0 tools. Among adults in a distance education course, learners were asked to compare their experiences using a wiki and a more typical discussion forum for collaborative learning. In general, they reported being uncomfortable with editing their peers' submissions to the wiki and having their submissions edited by others, indicating that the sociability of Web 2.0 technologies may be a relevant consideration (Kear et al. 2010). With additional exposure to the technologies, however, some users reported less concern over both usability and sociability (ibid).

Virtual worlds are another technology used for engaging adults in active and collaborative learning. A special type of immersive simulation, virtual worlds provide an engaging experiential learning environment by constructing "real-world" situations where users actively explore and generate learning content with virtual counterparts, like "avatars" or "agents" (Broadribb and Carter 2009). Virtual worlds, like the widely used Second Life, are focused primarily on socializing, exploring, and building (Montoya, Massey, and Lcokwood 2011).[45] Additionally, a key feature of virtual worlds, as with games, is that they encourage all learners to try new things and feel comfortable failing, so that they learn from their experiences (Grant, Huang, and Pasfield-Neofitou 2013). In workforce training and education, virtual worlds tend to be used to simulate accident scenarios in health and safety education, as well as in language learning (Tornsaufer 2013).

Researchers argue that the social interactions (between learners and instructors and between learners and other learners) that can occur within virtual worlds are vital to the learning process, particularly for adults (Heindel 2014; Tornsaufer 2013). With virtual worlds, users can synchronously interact with instructors and other learners, as in a face-to-face classroom, yet do so safely and anonymously (Wang 2011; Ott 2011; Kim, Lee, and Thomas 2012; Montoya, Massey, and Lcokwood 2011; Grant, Huang, and Pasfield-Neofitou 2013). Learners in virtual worlds, especially more physically isolated learners, thus often feel a strong sense of presence, which research suggests is conducive to learning (Grant, Huang, and Pasfield-Neofitou 2013; Kim, Lee, and Thomas 2012; Mancuso, Chlup, and McWhorter 2010).

Early studies of learning outcomes in virtual worlds, most commonly Second Life, indicate that these interventions may be quite effective at yielding positive learning outcomes in a variety of settings, including developmental reading education and continuing professional development in healthcare (Burgess 2010; Wiecha 2010). Burgess's (2010) quasi-experimental study, which was discussed in Chapter 5, found improvements in reading achievement associated with supplemental reading instruction in Second Life. Wiecha (2010) trained practicing primary care physicians in an hour-long Second Life course on the topic of type-2 diabetes. Assessing pre-post changes in confidence and performance in test cases, the authors report increases in confidence in selecting and adjusting insulin doses and improvement in providing correct insulin initiation plans.

Under some circumstances, the anonymity or "leveling of the playing field" afforded to learners in a virtual world may act as one mechanism through which these improvements may arise. Evans (2011)

---

45 While they may share some design features with popular multiplayer online games, virtual worlds do not adhere to the traditional definition of games in that they do not have set goals or structured interactions.

found that nursing students have reported being satisfied with the ability to practice their interpersonal conflict management skills anonymously in virtual worlds like Second Life. These students engaged synchronously in partially scripted role-playing scenarios common in a hospital setting, and after completion of the exercises, faculty discussed learning content and examples of conflict management strategies. Students were surveyed about their experience and their own perceptions of the simulation's effectiveness. Nearly three-quarters of the students reported being more comfortable exploring conflict in a virtual setting that in person, and about 90 percent were able to apply management skills taught in the course (Evans 2011).

Despite the high level of comfort associated with the anonymity in virtual worlds, the actual learning impacts require continued exploration. For example, in a brief half-day workshop on providing and receiving feedback, learners initially completed a traditionally designed workshop before being randomly assigned to a skills practice exercise in a face-to-face or virtual environment in Second Life (Broadribb and Carter 2009). The practice interventions were short, lasting about 20 minutes, but students from both groups self-reported significant improvement in their perceived abilities and confidence in providing and receiving feedback.

It is also important to note that virtual technologies can be difficult to navigate for users unfamiliar with technology due to complex interfaces (Grant 2013). Having to get accustomed to the environment can detract from the time for learning, and students' level of immersion and engagement, as with games, can lead to addiction and use for activities unrelated to learning (Connor 2012; Mancuso, Chlup, and McWhorter 2010). Also, by including educational content, they may lose the game-like appeal. As discussed in Chapter 5, while coursework completed in Second Life can improve developmental reading achievement, those outcomes may not correlate with enjoyment or engagement in the virtual world (Burgess 2010). For this, and other reasons, most Web-based learning experiences currently do not take full advantage of virtual technologies (Kriegel 2013).

6.5 Utilizing Data

Technological advancements also have improved learning more indirectly by increasing the ability of instructors and course designers to understand how learners are interacting and engaging with course content. The "digitalization" of educational data is growing (Siemens 2013; Ferguson 2012; Romero and Ventura 2010; Romero and Ventura 2013; Baker and Siemens 2013). Software automates the process of collecting micro-level data—at the level of the keystroke or second—on learner activities. Beyond allowing instructors to individualize instruction (as described above), these data also can be used to more indirectly support learning. For instance, data can be used to deliver feedback to learners, provide assessment to inform instruction, and enable learners to practice skills and signal competencies. Furthermore, they may allow providers to better understand the market for workforce training and education (West 2012; Russell, Lippincott, and Getman 2013).

Learning Analytics focus on addressing the application of tools and methods for exploring educational data (Siemens 2013; Ferguson 2012). The resulting data are then used to support human judgment, providing instructors with the tools to interpret and effectively use educational data to dynamically adapt their instructional methods (Romero and Ventura, 2012). The granularity of the data and the built-in tools for analyzing those data allow for nearly instantaneous, structured formative assessment by instructors. A prevalent example of a tool for learning analytics is a Learning Management System (LMS), such as Blackboard or Moodle. An LMS can track learner progress and learner interaction with content, resources, services, and people (Russell, Lippincott, and Getman 2013; Macfadyen and Dawson 2010). For example, the LMS might track how long learners spend on a given online page, their common mistakes, and the order in which they navigate through material. Instructors can use these data to better focus their instruction on problem areas and even to predict the success (or drop-out) of learners (Siemens and Long 2011). These data are not only useful to instructors but to individual learners as well. Specifically, they enable learners to signal their progress, achievements and abilities, competencies mastered, and time allocated to each. This is particularly relevant for those preparing for professional or occupational certifications that are highly structured and competency based.

Highly detailed analytics are also being used by private employers to support their human resource functions. Using, for instance, video simulations or Web-based tests, major corporations are mining the high volume of “big data” to help pinpoint the kind of worker who might thrive in a particular job. In 2013, more than a third of new hires reported taking such a test, compared with 18 percent in 2008, according to data from the Integrated Talent Management Services of Corporate Executive Board, a member-based advisory company (Halzack 2014).

These same types of data are also being used in colleges and universities to assemble an individually based **digital transcript** or **e-portfolio.** Digital transcripts can serve as a comprehensive, unified, and portable learning record that includes everything from learning style to academic and certification achievements (Barrett 2012). They can follow the learner from one learning program to another to aid instructors in individualizing and customizing instruction across courses. Digital Badges would be one part of this portfolio, allowing adults to comprehensively document and signal to employers their competencies, technical skills, and achievements (Foster 2013; Sullivan 2013; Finkelstein, Knight, and Manning 2013). Additionally, this record and the aforementioned resources can allow for increased targeting, as well as signaling to employers of vocational competency (Barrett 2012).

The use of **big data,** essentially massive amounts of highly detailed, micro-level information, is another emerging trend that makes it possible to examine and diagnose the learning experience for insights and early warnings regarding performance and learning approaches (West 2012). These data may be most useful in the aggregate, when they cover learning across numerous courses, programs, and fields of study. Russell (2013) speculates that in the coming years “Big data analytic methods [may be] used to predict behaviors, tailor messages, and create social networks could have powerful applications to educational assessment.” Macfadyen and Dawson (2010), for example, in an exploratory study, demonstrated that student-level data collected from an LMS, such as number of forum postings, mail messages sent, and assessments completed, can be used to identify at-risk or failing students. Their predictive model correctly identified as “at-risk” 81 percent of students who ultimately achieved a failing grade.

Other applications of big data include providing data on skills needs and demands to job seekers and training providers. The U.S. Department of Commerce, National Institute of Standards and Technology’s Hollings Manufacturing Extension Partnership (MEP) is implementing a data-gathering tool that will help small manufacturers capture their current skill needs as well as their future skill demands. The data can inform community colleges, apprenticeship programs, and Workforce Investment Boards about the current and changing skill needs of advanced manufacturing (White House 2014b). Similarly, Apploi, which aims to connect job seekers and employers using mobile and online technology, is announcing a commitment to use real-time data about local employer needs to develop a new tool that shows job seekers where the greatest job demand is geographically and by sector. Focusing primarily on jobs in select sectors for now (retail, entertainment, and hospitality), this tool also provides customized recommendations about what education and training is needed for those positions In addition, job seekers will be able to learn from their job search by receiving personalized feedback based on their skills, interests, and local job needs (White House 2014b).

This use of big data is emerging and understudied given the current diversity of and fragmentation in the field. Russell, Lippincott, and Getman (2013) note that making informed, data-driven decisions will depend on the development of interoperability standards and tools that enable data to be pulled from different systems and combined for analysis (Russell, Lippincott, and Getman 2013). At present, there are limited standards governing the storage and exchange of data across classes, across programs, and across learning management systems.

6.6 Summary

TBL has broadened and evolved significantly with the emergence of new technological platforms, applications, and approaches to technology and in response to earlier experiences with older iterations of TBL. More recent trends include a cross-cutting emphasis on enhancing the capacity and flexibility of these technologies to enhance the effectiveness and individualization of, and access to, learning. Of particular note are TBL designs that do the following:

- **Improve access to and the scalability of learning**, for instance through the spread of Open Educational Resources, publically available instructional materials, and repositories for these resources, and the increased availability of mobile learning technologies and applications.
- **Individualize learning** directly by facilitating modular, competency-based learning as well as artificial intelligence to create adaptive learning systems and Intelligent Tutoring Systems.
- **Enhance learner engagement**, for instance, by facilitating game-based learning, making learning more incentive-based and fun, and creating immersive simulations, which allow the development and practice of skills in realistic, but controlled and therefore safe, environments.
- **Promote highly-interactive, social learning**, for instance, the use of Web 2.0, social media, and collaborative approaches to content generation and learning, and virtual worlds.
- **Mine data to shape learning opportunities beyond a given TBL application**, for instance, the application of Learning Analytics to better understand learning; the analysis of big data to better inform TBL design; and the synthesis of data to create transferable e-portfolios for learners to showcase their skills.

Overall, the increasing promise of TBL and its continued innovation depends on the interconnectedness of these trends and combinations of these technologies. These synergies may ultimately enable new approaches to instruction and learning in more accessible, individualized, and effective ways.

7. Conclusion

As policymakers, trainers, and educators analyze and monitor the ongoing evolution of TBL, this literature review provides an opportunity to take stock of what the field has learned and the critical questions that remain going forward. In discussing these insights, policymakers should remember that TBL is complex and multifaceted. While TBL is often discussed as a singular entity or intervention, it is anything but. The inherent variations in technologies, communication and delivery platforms, and skill-building environments provide endless possible combinations of learning opportunities that must be discussed and examined within their own unique training contexts. At some level, reviews such as this one have the potential to be counterproductive if they falsely convey an element of homogeneity or uniformity to TBL and steer readers towards over-simplification.

It is also important to note that TBL largely operates in an environment that can be characterized as "let[ting] 1,000 flowers bloom." This is particularly true as we transition to the new generation of technologies driven by sophisticated data analytics, countless individual "apps," OERs, and real-time customized feedback. While efforts are under way to overlay consistency and organization on this system (e.g., digital badges and other nascent credentialing efforts; online repositories and libraries for content; empirical research; standards for interoperability), this dynamic environment adds to the challenges of analyzing and discussing TBL as a singular entity.

With these caveats underscored, this review identified a number of broad and specific findings. At the same time, it identified important gaps in our collective knowledge and research challenges that lie ahead. Each of these areas is briefly summarized below.

7.1 Key Findings

The research highlighted a number of important findings with respect to the dynamics of TBL implementation and adoption as well as the challenge of designing and implementing effective learner interventions.

- **Definitive evidence of the effectiveness of particular TBL designs for employment outcomes is limited.** In assessing the question of TBL effectiveness, much of the evidence for particular designs is mixed and limited to more proximate workforce-related outcomes. The clarity and definitiveness of the research is further complicated by the rapid evolution of the technology and its applications. This may have limited the researchers' motivation to fully explore more distal (i.e., longer-term) employment measures and often made existing results prematurely obsolete.
- **The effectiveness of technology-only solutions is particularly unclear**. More standard distance learning designs (asynchronous self-study) vary widely from producing negative to positive impacts on workforce-related outcomes, including knowledge and implementation of skills. Technology-only solutions that allow for social learning (e.g., synchronous work in a computer lab) are more likely to be as effective as traditional interventions in affecting workforce-related learning. However, technology-only solutions can also be associated with some negative impacts on satisfaction, motivation, and attitude.
- **Interaction with instructors and learners is valuable.** Blended interventions, which rely on some element of traditional instruction and human interaction, are generally as effective as traditional interventions in achieving workforce-related outcomes. Additionally, the evidence

suggests that technology-only interventions may be more effective if they integrate more engagement with content (e.g., allowing learners to actively drive or engage with the material)

- **TBL faces many of the same challenges that plague more traditional forms of instruction**. Despite the diverse and rapidly evolving technologies and applications, TBL faces the ongoing challenge of full learner engagement, productive group interaction, and the individualization of instruction and content to learner needs. Clearly, the context and technologies have evolved, but the core challenges remain. While emerging technologies and applications hold the potential to productively address some of these challenges they also hold the potential to exacerbate them (e.g., learner isolation in a MOOC environment).
- **Provider concerns over development and/or migration costs remain pervasive.** While TBL potentially could be extremely cost-efficient, the fixed infrastructure, development, and transition (i.e. translating content to an electronic format) costs remain daunting to institutions looking to offer more TBL options. These concerns are particularly prominent in the public workforce training and educational arenas where resource constraints and investment trade-offs are magnified. Additionally, individual instructors express these cost-related concerns more in terms of time available to integrate additional components into their curricula.
- **Technological literacy continues to be a challenge.** Despite the perceived ubiquity of computers and mobile devices, comfort with technology continues to be a challenge. It appears to be most influential at the front end by limiting learners' willingness to pursue TBL. The most problematic implication is not so much a single missed course or program. Rather, it is the missed opportunity to continue building a solid basic skills foundation for the 21st century. This skill base has expanded from its long-standing emphasis on literacy and numeracy to include what OECD's PIACC refers to as "problem solving in a technology rich environment," an area where nearly two-thirds of Americans are deemed low skilled. Understanding the scope of this complex issue remains an important step in addressing issues of access and stability in a TBL setting.
- **Employer acceptance of TBL-based credentials is not universal.** Particularly germane to the workforce system is the perspective of employers. While awareness of and comfort with TBL is no doubt evolving, the literature continues to suggest that employers often retain a preference for job candidates trained through more traditional methods. It is also telling that training institutions' investments in TBL tend not to mirror their broader training investments in high-growth, high-demand occupations. These decisions may suggest a reluctance to deviate from what employers want in these "high stakes" sectors.
- **TBL offerings are increasingly widespread, but demand and use has lagged by comparison**. The pace of TBL adoption by a provider and the pace of adoption by users and learners are not always in sync. The literature shows a steady increase in educational institutions offering of both courses with technological components as well as full TBL programs of study. This trajectory has generally not been matched by the proportion of learners in these institutions who make use of these TBL offerings. This lag further complicates already complex investment decisions facing TBL providers. Understanding the relative importance of these factors and their interrelationships is critical to effectively managing future investments in TBL.
- **The emerging generation of learning technologies holds enormous promise but still require rigorous evaluation.** The integration of artificial intelligence, learner analytics, "big data" mining, and social and game-based learning into the emerging generation of TBL tools provides

unprecedented potential and promise. These portend significant improvements in the areas of scalability of learning, customization of design and content, as well as broad learner engagement. Given the complexity of both design and implementation, it is critical that these emerging tools are subject to rigorous research to conclusively identify their effectiveness and the context in which they generate the greatest benefit.

7.2 Design Challenges

The literature sheds light on a number of complex issues where a more nuanced understanding is critical in designing effective TBL solutions:

- **Determine the proper balance between technology and "traditional" instruction in blended models**. Both the public workforce system and the network of career and technical education providers have placed extensive emphasis on the use of blended instructional models. At their most basic, the aim of these models is to integrate some degree of traditional, individualized instruction or support in a technology context or to supplement traditional instruction with technology. The aim of this design is to both maximize learning and limit isolation. The exploration and evaluation of more complex blended learning models is particularly critical in the workforce development arena since the instruction must often integrate skill-building that is not easily adaptable to technology-only education. This includes, for instance, clinical and lab-based skills in healthcare and diagnostic and hands-on repair in advanced manufacturing.
- **Design instruction that effectively addresses multiple dimensions of learner engagement:** Much of the research points to the importance of learner interaction and full learner engagement. Less than full engagement of learners has the potential to contribute to isolation, "social loafing," attenuated competency development and, ultimately, compromised outcomes. This is a multi-faceted issue that has implications particularly in course design, instructional quality, choice and use of technology, and institutional support for learners. Each of these dimensions must be fully examined to determine their unique contribution to a productive learning engagement.
- **Integrate the perspective of employers**. Employers are critical stakeholders in the workforce development equation. Employer commitment to offering TBL has grown steadily in recent years to the point where nearly one-third of their training hours are provided using technology (Green and McGill 2011). What has yet to be determined is if this growth in internal use reflects a similar confidence when hiring external candidates whose preparation or certification has been achieved through exclusive or partial reliance on TBL.
- **Target opportunities for standardized content and large-scale delivery.** The public workforce development system continues to focus its training resources on a select set of high-growth sectors and occupations (e.g., healthcare, IT, advanced manufacturing). At the same time the system must remain committed to seeking increasingly cost-efficient developmental and delivery options. To these ends, it is important that future initiatives fully explore the feasibility of using more standardized "off the shelf" content available through third-party developers, for instance, publishers, equipment makers, and industry associations. When delivered at a large scale, TBL holds the potential to cost-effectively expand the reach and capacity of the public workforce system. Targeted research is needed to identify appropriate content, examine logistical feasibility, and confirm the potential to achieve competency requirements for specific workforce populations, contexts, and learning goals.

- **Provide effective professional development and support for AJC staff and training providers**. Typically discussions of digital or technological literacy apply primarily to the learners and their readiness to pursue training or education via TBL. The literature, however, suggests that the access to and value of TBL is also critically dependent upon the extent to which AJC staff and service providers are ready to assess, recommend, and facilitate engagement with TBL. Maintaining this staff readiness is particularly critical given the rapid evolution of technologies and TBL options. The challenge is magnified in the context of the highly decentralized workforce development system where consistency of service quality remains a constant concern.
- **Further explore the addition and substitution of technology:** Some very preliminary evidence suggests that "dosage matters" and that the addition of technology to traditional instruction generally yields positive results. It is important to understand whether this is simply a matter of "more content is better" or whether the technology in fact plays some role. At the same time it is important for curriculum designers to understand how to trade off TBL and traditional instruction to most cost-efficiently achieve a standard result (e.g., competencies needed to pass a certification exam).

7.3 Research and Measurement Challenges

Based on these issues it is simultaneously important to structure future research and evaluation so as to maximize the quality and utility of the evidence. The literature suggests several important priorities:

- **Extend the time horizon.** The majority of rigorous research studies examined only shorter-term outcome measures of competency achievement or program satisfaction. Comparatively little emphasis has been placed on the longer-term retention of these skills. More importantly, the research has yet to extend its time horizon to determine the impacts of TBL on important workforce development outcomes such as employment stability and earnings.
- **Link proximal and distal outcomes.** In addition to tracking longer-term workforce specific outcomes and impacts, it is equally important to understand their connection to more proximal measures. These analyses are critical for 1) refining hypotheses about the dynamics of TBL and 2) identifying reliable proxy measures that can contribute to ongoing performance measurement and research efforts. For instance, it is particularly important to refine measures of learner engagement (e.g., attendance, time on task, assignments completed, use of communication tools) and determine the extent to which they contribute to variation in short-term outcome measures, such as completion or competency achievement. Similarly, it is valuable to identify drivers of learner satisfaction and the extent to which they ultimately lead to longer-term workforce development outcomes.
- **Focus on more cutting-edge technologies.** The evolving generation of Web-based learning tools (e.g., Web 2.0) has the potential to deliver more individualized, learner-centered experiences shaped by real-time feedback. This means that learner engagement efforts can potentially focus on an individual rather than on the more daunting task of engaging a cohort of learners around static content. It remains an open and long-term question if such customized content generates commensurate gains in workforce-related outcomes.

- **Recognize the importance of more precise metrics.** An increasingly sophisticated exploration of TBL use and effectiveness cannot be undertaken without more precise definitions and assessments. Much of this imprecision is inherent in the far-reaching and inclusive nature of the term "technology-based learning." Fully diagnosing and evaluating the effectiveness of specific interventions requires a commitment to, for instance, establishing more precise measures of blended or hybrid instruction that reflect the exact nature and intensity of personal support.
- **Expand the emphasis on covariates.** Research to date has largely focused on the overarching question, "Does TBL work?" Moving forward, the research agenda must seek to unpack the types of populations, program designs, and supports needed for TBL to be cost-effectively deployed for workforce development.

7.4 The Next Step

One of DOL's aims in sponsoring this literature review was to identify areas for future research on use of TBL in the workforce system. There are many options available for such research, covering a broad spectrum of learning and skill-building arenas such as:

- **Basic literacy and number skills.** The lack of these foundational skills is a significant barrier to advancement in the labor market, and significantly improving these skills among some adult workers has been challenging. Developing enhanced technology-based interventions, linked to other employment and training services, adult education, developmental educations, or in employer-based approaches, might be an area for further research.
- **Occupational skills.** Testing enhanced TBL programs in high-growth occupations could build on the already considerable investments have been made in the healthcare and IT sectors, both of which provide varied opportunities for the integration of TBL.
- **Job readiness and employability skills.** These skills are sometimes referred to as "soft" skills and emphasize proper workplace behaviors—including dress, punctuality, communication, and conflict resolution—upon which employers often place more value than on "hard" occupational skills. Developing and testing enhanced forms of TBL to reinforce these skills might be worth exploring.
- **Job search skills.** Developing these skills is a core function of the workforce system, and finding ways to use technology to reinforce them might be worth exploring. This might be especially useful in regard to promoting career pathway approaches, which are premised on the ability of participants to find new jobs and occupations within career ladders and lattices.
- **Career advising/counseling.** While this does not entail direct learning or skill-building in the traditional sense, it is nonetheless an essential AJC responsibility and an arena where technology might be tried to help to help customers make better choices among career and training options, in order to improve completion and training related employment in the workforce system.
- **Technological literacy.** Given the ubiquity of technology, technological literacy is a basic skill necessary to succeed in today's job market and one that might be ripe for testing new ways to build these skills.

Consideration of TBL research options, should be driven by one or more of the most pressing questions that repeatedly surfaced throughout the review of literature, including the following:

- Can more active learner engagement be promoted through the use of emerging technologies such as simulations and game-based designs?
- Can learning content be better individualized through the use of adaptive software?
- Can access to learning opportunities be improved through the use of TBL, and thus improve the overall cost-efficiency of the public workforce system?
- Can the preparedness of learners, instructors, and workforce professionals be ensured in order to maximize the potential of investments in TBL?

Addressing these questions will help DOL to systematically explore new possibilities for using TBL productively in the public workforce system.

Works Cited

Abrami, Philip C, Robert M Bernard, Eva M Bures, Eugene Borokhovski, and Rana M Tamim. 2011. "Interaction in Distance Education and Online Learning: Using Evidence and Theory to Improve Practice." *Journal of Computing in Higher Education* 23 (2-3):82-103.

Abrams, Sandra Schamroth, and Hannah R Gerber. 2013. "Achieving through the Feedback Loop: Videogames, Authentic Assessment, and Meaningful Learning." *English Journal* 103 (1):95-103.

Adams, Cralee J. 2014. "Revised GED Ushers in New Era With More Options." *Education Week*.

Adams, Jonathan, and Margaret H. DeFleur. 2006. "The Acceptability of Online Degrees Earned as a Credential for Obtaining Employment." *Communication Education* 55 (1):32-45.

Adams, Jonathan, Margaret H. DeFleur, and Gary R. Heald. 2007. "The Acceptability of Credentials Earned Online for Obtaining Employment in the Health Care Professions." *Communication Education* 56 (3):292-307.

Aljohani, Naif R, and Hugh C Davis. 2012. Learning analytics in mobile and ubiquitous learning environments. [pub? org? city?]

Allen, I Elaine, and Jeff Seaman. 2013. *Changing Course: Ten Years of Tracking Online Education in the United States*: ERIC (Education Resources Information Center). Institute of Education Sciences.

Allen, I Elaine, and Jeff Seaman. 2014. *Grade Change: Tracking Online Education in the United States*: ERIC (Education Resources Information Center). Institute of Education Sciences.

Allen, I. Elaine, and Jeff Seaman. 2011. Going the Distance: Online Education in the United States, 2011. Babson Survey Research Group.

Alliance for Excellent Education and Mozilla Foundation. 2013. Expanding Education and Workforce Opportunities Through Digital Badges.

Angelino, Lorraine M, Frankie Keels Williams, and Deborah Natvig. 2007. "Strategies to Engage Online Students and Reduce Attrition Rates." *Journal of Educators Online* 4 (2):n2.

Apostol, Silviu, Loredana Zaharescu, and Isabelle Alexe. 2013. "Gamification of Learning and Educational Games." In *The 9th International Scientific Conference: eLearning and Software for Education*. Bucharest.

Aragon, Steven R, and Elaine S Johnson. 2008. "Factors Influencing Completion and Noncompletion of Community College Online Courses." *American Journal of Distance Education* 22 (3):146-158.

Arbaugh, JB, Ashay Desai, Barbara Rau, and Balakuntalam S Sridhar. 2010. "A Review of Research on Online and Blended Learning in the Management Disciplines: 1994-2009." *Teaching & Learning* 7:39-55.

Askov, Eunice N, Jerome Johnston, Leslie I Petty, and Shannon J Young. 2003. Expanding Access to Adult Literacy with Online Distance Education. Edited by Department of Education, Office of

Vocational and Adult Education. Boston, MA: National Center for the Study of Adult Learning and Literacy.

Bai, Xin, and Michael B Smith. 2010. "Promoting Hybrid Learning through a Sharable eLearning Approach." *Journal of Asynchronous Learning Networks* 14 (3):13-24.

Baker, Ryan, and George Siemens. *Educational Data Mining and Learning Analytics* 2013 [cited 03/12/14. Available from http://www.columbia.edu/~rsb2162/BakerSiemensHandbook2013.pdf.

Barefield, Amanda C, Jim Condon, Charlotte McCuen, and Nanette B Sayles. 2010. "Incorporating the e-HIM [R] Virtual Lab into the Health Information Administration Professional Practice Experience." *Journal of Asynchronous Learning Networks* 14 (3):68-73.

Barrett, Bob. 2012. Creating E-Portfolios in the Virtual Learning Environment: A Technologic Tool for Academic Assessment and Career. *International Proceedings of Economics Development & Research* 47.

Batchelder, John Stuart, and John R Rachal. 2000. "Efficacy of a Computer-Assisted Instruction Program in a Prison Setting: An Experimental Study." *Adult Education Quarterly* 50 (2):120-133.

Beeckman, Dimitri, Lisette Schoonhoven, Hilde Boucque, Georges VanMaele, and Tom Defloor. 2008. "Pressure Ulcers: E-learning to Improve Classification by Nurses and Nursing Students." *Journal of Clinical Nursing* 17:1697-1707.

Benchmark Learning. "The Future of e-Learning: Understanding the ROI Benefits of Modern Corporate Training Tools."Minneapolis, MN.

Bernard, Robert M, Philip C Abrami, Eugene Borokhovski, C Anne Wade, Rana M Tamim, Michael A Surkes, and Edward Clement Bethel. 2009. "A Meta-Analysis of Three Types of Interaction Treatments in Distance Education." *Review of Educational Research* 79 (3):1243-1289.

Betts, Kristen, Alex Cohen, Daniel Veit, Henry C Alphin, and Chanel Broadus. 2013. "Strategies to Increase Online Student Success for Students with Disabilities." *Journal of Asynchronous Learning Networks* 17 (3).

Betts, Kristen, Bill Welsh, Kelly Hermann, Cheryl Pruitt, Gaeir Dietrich, Jorge Trevino, Terry Watson, Mike Brooks, Alex Cohen, and Norman Coombs. 2013. "Understanding Disabilities & Online Student Success." *Journal of Asynchronous Learning Networks* 17 (3).

Bishop, Amy Renee. 2010. "The Effect of a Math Emporium Course Redesign in Developmental and Introductory Mathematics Courses on Student Achievement and Students' Attitudes Toward Mathematics at a Two-Year College." Thesis. The University of Southern Mississippi.

Boja, Catalin, Paul Pocatilu, and Cristian Toma. 2013. "The Economics of Cloud Computing on Educational Services." *Procedia Social and Behavioral Sciences* 93:1050-1054.

Bowen, William G, and S Ithaka. 2012. *Interactive learning online at public universities: Evidence from randomized trials*. Ithaka S+ R. ITHAKA: New York.

Broadribb, Steph, and Chris Carter. 2009. "Using Second Life in Human Resource Development." *British Journal of Educational Technology* 40 (3):547-550.

Brown, Quincy. 2009. Mobile Intelligent Tutoring System: Moving Intelligent Tutoring Systems Off The Desktop, Drexel University.

Burgess, Kimberly R. 2009. Social Networking Technologies as Vehicles of Support for Women in Learning Communities. In *New Directions for Community Colleges*: Wiley InterScience.

Burgess, Melissa. 2010. Optimal Experience and Reading Achievement in Virtual Environments Among College Level Developmental Readers, Department of Language, Literacy, and Special Populations, Sam Houston State University.

Bynner, John, Steve Reder, and Samantha Parsons. 2010. The three divides: "The Digital Divide and its Relation to Basic Skills and Employment in Portland, USA and London, England." National Research and Development Centre. London, UK.

Carl D. Perkins Career and Technical Education Improvement Act of 2006. Public Law 109-270.

Carruth, Paul J, and Ann K Carruth. 2013. "Educational and Financial Impact of Technology on Workforce Development." *American Journal of Business Education* 6 (5):513-520.

Carter, Jeff, and Judy Titzel. 2003. *Technology in today's ABE classroom: A look at the technology practices and preferences of adult basic education teachers*: World Education. Boston, MA.

Center for the Study of Adult Literacy. Accessed September 5, 2014. http://csal.gsu.edu/content/project-overview.

Community College Research Center. *Center for Analysis of Postsecondary Readiness.* 2014. Accessed September 5, 2014. http://ccrc.tc.columbia.edu/research-project/center-analysis-postsecondary-readiness.html.

Connor, Kelley. 2012. Immersive Virtual Reality Environments for Perioperative Nursing. *Perioperative Nursing Clinics* 7 (2):251-255.

Cox, Rebecca. 2005. "Online education as institutional myth: Rituals and realities at community colleges." *The Teachers College Record* 107 (8):1754-1787.

D'Mello, Sidney K, Nia Dowell, and Arthur Graesser. 2011. Does it really matter whether students' contributions are spoken versus typed in an intelligent tutoring system with natural language? Journal of Experimental Psychology: Applied 17 (1):1.

Dalton, Ben, Erich Lauff, Robin Henke, Martha Alt, and Xiaojie Li. 2013. From Track to Field: Trends in Career and Technical Education across Three Decades. Online Submission.

Deniozou, Thaleia. *Mobile Games for Adult Learning: What's the Appeal?* eLearning Industry 2013. Available from http://elearningindustry.com/mobile-games-for-adult-learning-what-is-the-appeal.

Diaz, Veronica. 2010. “Web 2.0 and emerging technologies in online learning.” *New Directions for Community Colleges* 2010 (150):57-66.

Dortch, Cassandria. 2014. *Career and Technical Education (CTE): A Primer.* Edited by Congressional Research Service. Washington, DC.

Dunham, Kate, Rachel Estrella, Jill Leufgen, and Jennifer Henderson-Frakes. 2011. "Evaluation of Technology-Based Learning Grants." Oakland, CA: Social Policy Research Associates.

Dunham, Kate, Rachel Estrella, and Annie Nyborg. 2010. "Evaluation of Technology-Based Learning Grants, Interim Report." Oakland, CA: Social Policy Research Associates.

Eckerman, David A, Christine A Lundeen, Andrew Steele, Heather L Fercho, Tammara A Ammerman, and W. Kent Anger. 2002. "Interactive Training Versus Reading to Teach Respiratory Protection." *Journal of Occupational Health* 7 (4):313-323.

Edgecombe, Nikki, Maria Scott Cormier, Susan Bickerstaff, and Melissa Barragan. 2013. "Strengthening Developmental Education Reforms: Evidence on Implementation Efforts From the Scaling Innovation Project." (CCRC Working Paper No. 61). New York, NY: Community College Research Center, Teachers College, Columbia University.

Ellinger, Andrea D. 2004. "The Concept of Self-Directed Learning and its Implications for Human Resource Development." *Advances in Developing Human Resources* 6 (158).

Evans, Dena A, and Anthony R Curtis. 2011. "Animosity, antagonism, and avatars: teaching conflict management in Second Life." *The Journal of nursing education* 50 (11):653-655.

Ferguson, Rebecca. 2012." Learning analytics: drivers, developments and challenges." *International Journal of Technology Enhanced Learning* 4 (5):304-317.

Finkelstein, Jonathan, Erin Knight, and Susan Manning. 2013. "The Potential and Value of Using Digital Badges for Adult Learners," draft for public comment. American Institutes for Research. Washington, DC.

Fisher, Joseph B, Donald D Deshler, and Jean B Schumaker. 1999. "The Effects of an Interactive Multimedia Program on Teachers' Understanding and Implementation of an Inclusive Practice." *Learning Disability Quarterly* 22:127-142.

Fletcher, J.D., and John E. Morrison. 2012. "DARPA Digital Tutor: Assessment Data." Institute for Defense Analyses. Alexandria, VA.

Foster, John C. 2013. "The Promise of Digital Badges." *Techniques*. 88 (8): 31-34.

Foster, Marcie, Julie Strawn, and Amy Ellen Duke-Benfield. 2011. "Beyond Basic Skills: State Strategies to Connect Low-Skilled Students to an Employer-Valued Postsecondary Education." Edited by CLASP Center for Postsecondary and Economic Success.Washington, DC.

Fulantelli, Giovanni, Davide Taibi, and Marco Arrigo. 2013." A semantic approach to mobile learning analytics." Paper read at Proceedings of the First International Conference on Technological Ecosystem for Enhancing Multiculturality. New York, NY.

Gallagher, Sean, and Geoffrey Garrett. 2013. "Disruptive Education: Technology-Enabled Universities." The United States Studies Centre, University of Sydney, Australia.

Gan, Katherine N., Glen Schneider, Eleanor Harvill, and Nicole Brooke. 2013. "Technology-Based Learning in the Workforce Investment System." Cambridge, MA: Abt Associates Inc.

Gatta, Mary L. 2005. *Not Just Getting By: The New Era of Flexible Workforce Development*. Lanham, MD: Lexington Books.

Ghadirli, Hossein Movafegh, and Maryam Rastgarpour. 2013. "An Adaptive and Intelligent Tutor by Expert Systems for Mobile Devices." *arXiv preprint arXiv:1304.4619*.

Githens, Rod Patrick, Timothy M Sauer, Fashaad L Crawford, and Kristin B Wilson. 2012. "Online Occupational Education in Community Colleges: Prevalence, Programming, and Connection with Workforce Development Needs." *Career and Technical Education Research* 37 (1):35-56.

Godwin-Jones, Robert. 2011. "Emerging Technologies: Autonomous Language Learning." *Language Learning & Technology* 15 (3):4-11.

Grant, Scott, Hui Huang, and Sarah Pasfield-Neofitou. 2013. "Language Learning in Virtual Worlds: The Role of FLA and Technical Anxiety." *SLACTIONS 2012*:36.

Grant, Scott, Hui Huang, and Sarah Pasfield-Neofitou. 2013. "Language Learning in Virtual Worlds: The Role of Foreign Language and Technical Anxiety". *Journal of Virtual Worlds Research* 6 (1).

Green, Michael, and Erin McGill. 2011. "State of the Industry, 2011." In *ASTD's Annual Review of Workplace Learning and Development Data*. Alexandria, VA: American Society for Training & Development.

Gretes, John A, and Michael Green. 1994. 'The Effect of Interactive CD-ROM/Digitized Audio Courseware on Reading Among Low-literate Adults.' *Computers in the Schools* 11 (2):27-42.

Gungor, Ramazan, and Esther Prins. 2011. "Distance Learning in Adult Basic Education: A Review of the Literature." Pennsylvania State University.

Hairston, Nancy, and Fredrick Muyia Nafukho. 2011. "Determining statistical significance between e-learning training versus traditional training in six different industry settings." *International Journal of Vocational Education and Trainin* 19 (1): 7-22.

Halzack, Sarah. 2014. "Online tests are the latest gateway to landing a new job." *The Washington Post*. May 8. Accessed September 9, 2014. http://www.washingtonpost.com/business/capitalbusiness/online-tests-are-the-latest-gateway-to-landing-a-new-job/2014/05/08/c5eebc6a-cb2d-11e3-95f7-7ecdde72d2ea_story.html

Hamdan, Noora, P McKnight, K McKnight, and K Arfstrom. 2013. "A review of flipped learning." Flipped Learning Network. Accessed July 2013.: *http://www. flippedlearning. org/cms/lib07/VA01923112/Centricity/Domain/41/LitReview* _

Harrell, Ivan, and Beverly Bower. 2011. "Student Characteristics That Predict Persistence in Community College Online Courses." *The American Journal of Distance Education* 25:178-191.

Hart, Carolyn. 2012. "Factors Associated With Student Persistence in an Online Program of Study: A Review of the Literature." *Journal of Interactive Online Learning* 11 (1):19-42.

Harting, Kathleen, and Margaret J Erthal. 2005. History of distance learning. *Information Technology Learning And Performance Journal* 23 (1):35.

Heindel, Allen J. 2014. "A Phenomenological Study of the Experiences of Higher Education Students with Disabilities with Online Coursework." Department of Secondary Education, University of South Florida.

Hetzner, Sonia, Christina M Steiner, Vania Dimitrova, Paul Brna, and Owen Conlan. 2011. Adult self-regulated learning through linking experience in simulated and real world: a holistic approach. In *Towards Ubiquitous Learning*. Springer.

Hignite, Karla, Richard N Katz, and Ronald Yanosky. 2010. "Shaping the higher education cloud." *An EDUCAUSE and National Association of College and University Business Officers (NACUBO) White Paper, May 21*.

Hodara, Michelle. 2011. Reforming Mathematics Classroom Pedagogy: Evidence-Based Findings and Recommendations for the Developmental Math Classroom. CCRC Working Paper No. 27. Assessment of Evidence Series. Community College Research Center, Columbia University.

Howard-Jones, Paul A, and RJ Martin. 2002. "The effect of questioning on concept learning within a hypertext system." *Journal of Computer Assisted Learning* 18 (1):10-20.

Hrubik-Vulanovic, Tatjana. 2013. "Effects of Intelligent Tutoring Systems in Basic Algebra Courses on Subsequent Mathematics Lecture Courses." College of Education, Health, and Human Services, Kent State University.

Hsu, Yu-Chen, Hsin Ning Jessie Ho, Chin-Chung Tsai, Gwo-Jen Hwang, Hui-Chun Chu, Chin-Yeh Wang, and Nian-Shing Chen. 2012. "Research Trends in Technology-Based Learning from 2000 to 2009: A Content Analysis of Publications in Selected Journals." *Educational Technology & Society* 15 (2):354-370.

Huang, Hsiu-Mei. 2002. "Toward constructivism for adult learners in online learning environments." *British Journal of Educational Technology* 33 (1):27-37.

Huang, Wen-Hao David, Seung-Hyun Han, Un-Yeong Park, and Jungmin Jamie Seo. 2010. "Managing employees' motivation, cognition, and performance in virtual workplaces: The blueprint of a game-based adaptive performance platform (GAPP)." *Advances in Developing Human Resources* 12 (6):700-714.

Hughey, Aaron W, and Charlene Manco. 2012. "An Examination of the Potential Relationship Between Technology and Persistence Among At-Risk College Students." *US-China Education Review, A* 2 (5):544.

Hurst, Heather M, and Diane Marks-Maran. 2011. "Using a virtual patient activity to teach nurse prescribing." *Nurse Education in Practice* 11 (3):192-198.

Hwang, Gwo-Jen, and Chin-Chung Tsai. 2011. "Research trends in mobile and ubiquitous learning: A review of publications in selected journals from 2001 to 2010." *British Journal of Educational Technology* 42 (4):E65-E70.

International Innovation. 2013. ImREAL Project: Immersive reflective experience-based adaptive learning.

Jenkins, Davis, and Workforce Strategy Center US. 2006. Career pathways aligning public resources to support individual and regional economic advancement in the knowledge economy: August 2006.

Johnson, Scott D, Angela D Benson, John Duncan, Olga N Shinkareva, Gail Diane Taylor, and Tod Treat. 2004. "Internet-Based Learning in Postsecondary Career and Technical Education." *Journal of Vocational Education Research* 29 (2):101-119.

Jones, Sharon Torrence. 2011. "Technology Integration in the Teaching and Learning Process in Career and Technical Education Programs in North Carolina." North Carolina State University, Raleigh, North Carolina.

Kalil, Tom, and Cristin Dorgelo. Request for Information: Advancing Learning Technology through Pull Mechanisms 2014 [cited September 5, 2014. Available from http://www.whitehouse.gov/blog/2014/01/14/request-information-advancing-learning-technology-through-pull-mechanisms.

Kapp, Karl M. 2012. "Games, Gamification, and the Quest for Learner Engagement." *T+D*.

Kasitz, Christine M. 2013. "Efficacy Enhancing Communication Within The Online Courseroom.", School of Education, Capella University.

Ke, Fengfeng, and Dean Kwak. 2013. "Online learning across ethnicity and age: A study on learning interaction participation, perception, and learning satisfaction." *Computers & Education* 61:43-51.

Kear, Karen, John Woodthorpe, Sandy Robertson, and Mike Hutchison. 2010. "From forums to wikis: Perspectives on tools for collaboration." *The Internet and Higher Education* 13 (4):218-225.

Kemp, Wendy C. 2002. "Persistence of Adult Learners in Distance Education." *American Journal of Distance Education* 16 (2):65-81.

Kidd, Trerry. 2010. *Online Education and Adult Learning: New Frontiers for Teaching Practice*: Information Science Reference.

Kim, Sahoon H, Jiyeon Lee, and Michael K Thomas. 2012. "Between Purpose and Method: A Review of Educational Research on 3D Virtual Worlds." *Journal of Virtual Worlds Research* 5 (1).

Kirschner, Paul A, John Sweller, and Richard E Clark. 2006. "Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching." *Educational Psychologist* 41 (2):75-86.

Koller, Vinz, Sandra Harvey, and Micheline Magnotta. 2006. "Technology-Based Learning Strategies." Oakland, CA: Social Policy Research Associates.

Kotrlik, Joe W, and Donna H Redmann. 2005. "Extent of technology integration in instruction by adult basic education teachers." *Adult Education Quarterly* 55 (3):200-219.

Kotrlik, Joe W, and Donna H Redmann. 2009. "Analysis of teachers' adoption of technology for use in instruction in seven career and technical education programs." *Career and Technical Education Research* 34 (1):47-77.

KPMG. 2006. "An Examination of the Delivery of Literacy Services at Job Corps Centers."

Kriegel, Jessica. 2013. "Differences in Learning Preferences by Generational Cohort: Implications for Instructional Design in Corporate Web-based Learning." Drexel University.

Kummerow, Andreas, Marcia Miller, and Rhonda Reed. 2012. "Baccalaureate Courses for Nurses Online and on Campus: A Comparison of Learning Outcomes." *American Journal of Distance Education* 26 (1):50-65.

Lemmer, Catherine A. 2013. "A View from the Flip Side: Using the'Inverted Classroom' to Enhance the Legal Information Literacy of the International LL. M. Student." *Law Library Journal* 105 (4).

LeNoue, Marvin, Tom Hall, and Myron A Eighmy. 2011. "Adult education and the social media revolution." *Adult Learning* 22 (2):4-12.

Levine, Alissa, Christoph Winkler, and Saul Petersen. 2010. "The CUNY Young Adult Program—Utilizing Social Networking to Foster Interdisciplinary and Cross-Cohort Student Communication during Workforce Training." *Journal of Asynchronous Learning Networks* 14 (3):74-80.

Lewis, Laurie, Debbie Alexander, and Elizabeth Farris. 1997. *Distance Education in Higher Education Institutions.* US Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics.

Lewis, Laurie, Kyle Snow, Elizabeth Farris, Douglas Levin, and Bernie Greene. 1999. "Distance education at postsecondary education institutions: 1997-1998." *Institutions* 1997:98.

Li, Qing, and K.A. Edmonds. 2005. "Mathematics and At-Risk Adult Learners: Would Technology Help?" *Journal of Research on Technology in Education* 38 (2):143-166.

Lin, Zu-Chin. 2013. "Comparison of Technology-Based Cooperative Learning with Technology-Based Individual Learning in Enhancing Fundamental Nursing Proficiency." *Nurse Education Today* 33:546-551.

Lindsay, Colin. 2005. "Employability, services for unemployed job seekers and the digital divide." *Urban Studies* 42 (2):325-339.

Liu, Simon Y., Joel Gomez, and Cherng-Jyh Yen. 2009. "Community College Online Course Retention and Final Grade: Predicatbility of Social Presence." *Journal of Interactive Online Learning* 8 (2):165-182.

Lokken, Fred, and Christine Mullins. 2014. "Trends in eLearning: Tracking the Impact of eLearning at Community Colleges." In *Distance Education Survey Results*, edited by Instructional Technology Council.

London, Manuel, and MJ Hall. 2011. "Unlocking the value of Web 2.0 technologies for training and development: The shift from instructor-controlled, adaptive learning to learner-driven, generative learning." *Human Resource Management* 50 (6):757-775.

London, Manuel, and MJ Hall. 2011. Web 2.0 support for individual, group and organizational learning. *Human Resource Development International* 14 (1):103-113.

Lowry, Ann E. 2007. "Effects of Online Versus Face-to-Face Professional Development with a Team-Based Learning Community Approach on Teachers' Application of a New Instructional Practice." School of Education, Johns Hopkins University.

Macfadyen, Leah P, and Shane Dawson. 2010. "Mining LMS data to develop an 'early warning system' for educators: A proof of concept." *Computers & Education* 54 (2):588-599.

Mancuso, Donna S, Dominique T Chlup, and Rochell R McWhorter. 2010. "A study of adult learning in a virtual world." *Advances in Developing Human Resources* 12 (6):681-699.

MANILA Consulting Group Inc. 2008. "Evaluation of the READ 180 Program in Job Corps Centers," draft report. McLean, VA.

Marshall, James, and Allison Rossett. 2011. "Mapping the e-learning terrain." *International Journal on E-Learning* 10 (2):169-198.

Martinez-Aceituno, Josep Antoni, Xavier Mas, Mildred Guinart, and Jesus Mendoza. 2010. "Web 2.0 in Corporate Training: New Possibilities for Implementing e-learning within Organisations." *International Journal of Advanced Corporate Learning* 3 (3).

Maxwell, Amita. 2012. "Technological Advancements in Methods of Training with Reference to Online Training: Impact and Issues for Organizations." *Journal of Arts, Science & Commerce* 3 (3).

Maxwell, Nan, Samina Sattar, DanaRotz, and Kate Dunham. 2013. "Evaluation of Programs Funded by Technology-Based Learning (TBL) Grants." Oakland, CA: Mathematica Policy Research.

McCain, Mary L. 2009. "The Power of Technology to Transform Adult Learning: Expanding Access to Adult Education & Workforce Skills Through Distance Learning." Council for Advancement of Adult Literacy.

McDonald, Katie, and Charlene M Smith. 2013. "The Flipped Classroom for Professional Development: Part I. Benefits and Strategies." *Journal of Continuing Education in Nursing* 44 (10):437-438.

McKane, P. Frank, and Barbara A Greene. 1996. "The Use of Theory-Based Computer-Assisted Instruction in Correctional Centers to Enhance the Reading Skills of Reading-Disadvantaged Adults." *Journal of Educational Computing Research* 15 (4):331-344.

McKay, Elspeth, and John Izard. 2012. "Investigating Online Training In Government Agencies: Designing Adaptive Web-Based Instructional Programmes To Reskill The Workforce." *International Journal of Business Research* 12 (3).

Means, Barbara, Marianne Bakia, and Robert Murphy. 2014. *Learning Online: What Research Tells Us about Whether, When and How*. London: Routledge.

Means, Barbara, Yukie Toyama, Robert Murphy, Marianne Bakia, and Karla Jones. 2010. "Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies." Washington, DC.

Merriam, Sharan B. 2001. "Andragogy and self-directed learning: Pillars of adult learning theory." *New Directions for Adult and Continuing Education* 2001 (89):3-14.

Miller, Susan Finn. 2010. "Promoting Learner Engagement when Working with Adult English Language Learners." CAELA Network Brief. Center for Adult English Language Acquisition.

Montoya, Mitzi M, Anne P Massey, and Nicholas S Lcokwood. 2011. "3D Collaborative Virtual Environments: Exploring the Link Between Collaborative Behaviors and Team Performance." *Decision Sciences* 42 (2).

Moody, Johnette. 2004. "Distance Education: Why are the Attrition Rates so High?" *Quarterly Review of Distance Education* 5 (3):205-210.

Mullins, Christine. 2013. "Trends in eLearning: Tracking the Impact of eLearning at Community Colleges." In *Distance Education Survey Results*, edited by Instructional Technology Council.

Muse Jr., Herbert E. 2003. "The Web-based Community College Student: An Examination of Factors that Lead to Success and Risk." *Internet and Higher Education* 6:241-261.

National Alliance for Partnerships in Equity. 2014. *Carl D. Perkins Career and Technical Education Act*. Accessed September 9, 2014. http://www.napequity.org/public-policy/current-laws-and-bills/carl-perkins-career-technical-education-act/.

Nicol, M.M., and A. Anderson. 2000. "Computer-assisted vs. Teacher-directed Teaching of Numeracy in Adults." *Journal of Computer Assisted Learning* 16:184-192.

Organisation for Economic Co-operation and Development (OECD). 2013. *OECD Skills Outlook 2013: First Results from the Survey of Adult Skills*. OECD Publishing.

Organisation for Economic Co-operation and Development (OECD). 2013. *Time for the U.S. to Reskill?*: OECD Publishing.

Offenholley, Kathleen H. 2012. "A Discourse Analysis of the Online Mathematics Classroom." *American Journal of Distance Education* 26 (4):236-248.

Ott, Kenneth D. 2011. "Technology and Adult Learning: Understanding E-Learning and the Lifelong Learner." *The International Journal of Technology, Knowledge and Society* 7 (3):31-36.

Pachler, N., B. Bachmair, J. Cook, and G. Kress. 2009. *Mobile Learning: Structures, Agency, Practices*: Springer.

Oxman, Steven, and William Wong. 2014. WHITE PAPER: ADAPTIVE LEARNING SYSTEMS.

Pantazis, Cynthia. 2002. "Maximizing E-Learning to Train the 21st Century Workforce." *Public Personnel Management* 31 (1):21-25.

Parchman, Stephen W, John A Ellis, Daniel Christinaz, and Merle Vogel. 2000. "An Evaluation of Three Computer-Based Instructional Strategies in Basic Electricity and Electronics Training." *Military Psychology* 12 (1):73-87.

Park, Ji-Hye, and Hee Jun Choi. 2009. "Factors Influencing Adult Learners' Decision to Drop Out or Persist in Online Learning." *Educational Technology & Society* 12 (4):207-217.

Parsad, Basmat, and Laurie Lewis. 2008." Distance Education and Degree-Granting Postsecondary Institutions: 2006-07." Washington, DC: National Center for Education Statistics, Institute of Education Sciences.

Pew Research Center. Mobile Technology Fact Sheet 2014 [cited September 5, 2014. Available from http://www.pewinternet.org/fact-sheets/mobile-technology-fact-sheet/.

Pimmer, Christoph, Norbert Pachler, and Graham Attwell. 2010. "Towards work-based mobile learning: what we can learn from the fields of work-based learning and mobile learning." *International Journal of Mobile and Blended Learning* 2 (4):1-18.

Pop, Anisoara. 2010. "The Impact of the New Technologies in Foreign Language Instruction Our Experience." *Procedia Social and Behavioral Sciences* 2:1185-1189.

Preusser, Melissa K, Lynn K Bartels, and Cynthia R Nordstrom. 2011. "Sexual Harassment Training: Person Versus Machine." *Public Personnel Management* 40 (1):47-62.

Prins, Esther, Brendaly Drayton, Ramazan Gungor, and Cathy Kassab. 2012. "Distance Learning for GED Students in Rural Pennsylvania." *The American Journal of Distance Education* 26:217-235.

Radford, Alexandria Walton. 2011. *Learning at a Distance: Undergraduate Enrollment in Distance Education Courses and Degree Programs*. Edited by U. S. Department of Education.

Reddy, Diane M, Raymond Fleming, and Laura E Pedrick. *Increasing Student Success: Evaluating the Effectiveness of U-Pace Instruction at UWM* 2012 Accessed September 5, 2014. https://net.educause.edu/ir/library/pdf/SEI1203.pdf.

Rohlman, Diane, David Eckerman, Tammara Ammerman, Heather Fercho, Christine Lundeen, Carie Blomquist, and W. Kent Anger. 2004. "Quizzing and Feedback in Computer-Based and Book-Based Training for Workplace Safety and Health." *Journal of Organizational Behavior Management* 24 (3):1-26.

Romero, Cristobal, and Sebastian Ventura. 2013. "Data mining in education." *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery* 3 (1):12-27.

Romero, Cristóbal, and Sebastián Ventura. 2010. "Educational data mining: A review of the state of the art." *IEEE Transactions on Systems, Man, and Cybernetics, Part C: Applications and Reviews* 40 (6):601-618.

Rossett, Allison, and James Marshall. 2010. "What Corporate Training Professionals Think About E-Learning Practitioners'views On The Potential Of E-Learning In The Workplace." *Journal of Asynchronous Learning Networks* 14 (2).

Roy, Andrée. 2010. "SMEs: How to Make a Successful Transition From Conventional Training Towards E-Learning." *International Journal of Advanced Corporate Learning* 3 (2).

Roy, Andree, and Louis Raymond. 2008. "Meeting the Training Needs of SMEs: Is e-Leanring a Solution?" *The Electronic Journal of e-Learning* 6 (2):89-98.

Russell, Michael, Joan Lippincott, and Joan Getman. 2013. "Connected teaching and personalized learning: Implications of the National Education Technology Plan (NETP) for adult education."

Schmeeckle, Joyce M. 2003. "Online Training: An Evaluation of the Effectiveness and Efficiency of Training Law Enforcement Personnel Over the Internet." *Journal of Science Education and Technology* 12 (3):205-260.

Segal, David, Peter Y Chen, Donald A Gordon, Christoph D Kacir, and Julius Gylys. 2003. "Development and evaluation of a parenting intervention program: Integration of scientific and practical approaches." *International Journal of Human-Computer Interaction* 15 (3):453-467.

Selwyn, Neil. 2004. Reconsidering political and popular understandings of the digital divide. *New Media & Society* 6 (3):341-362.

Shea, Peter, and Temi Bidjerano. 2014. "Does online learning impede degree completion? A national study of community college students." *Computers & Education* 75:103-111.

Sher, Ali. 2009. "Assessing the Relationship of Student-Instructor and Student-Student Interaction to Student Learning and Satisfaction in Web-based Online Learning Environment." *Journal of Interactive Online Learning* 8 (2):102-120.

Siemens, George. 2013. "Learning Analytics The Emergence of a Discipline." *American Behavioral Scientist* 57 (10):1380-1400.

Siemens, George, and Phil Long. 2011. "Penetrating the fog: Analytics in learning and education." *Educause Review* 46 (5):30-32.

Silver-Pacuilla, Heidi. 2008. "Investigating the Language and Literacy Skills Required for Independent Online Learning." National Institute for Literacy.

Sitzmann, Traci. 2011. "A Meta-Analytic Examination of the Instructional Effectiveness of Computer-Based Simulation Games." *Personnel Psychology* 64:489-528.

Sitzmann, Traci, Katherine Ely, Bradford S Bell, and Kristina N Bauer. 2010. "The effects of technical difficulties on learning and attrition during online training." *Journal of Experimental Psychology: Applied* 16 (3):281.

Sitzmann, Traci, Kurt Kraiger, David Stewart, and Robert Wisher. 2006. "The Comparative Effeciveness of Web-Based and Classroom Instruction: A Meta-Analysis." *Personnel Psychology* 59:623-664.

Smith, Ashley A. 2014. "Tougher GED Tests Mean Fewer Take Exam, Pass." *USA Today*.

Smith, CM, and K McDonald. 2013. "The Flipped Classroom for Professional Development: Part II. Making Podcasts and Videos." *Journal of continuing education in nursing* 44 (11):486-487.

Snyder, Ilana, Anne Theresa Jones, and Joseph Lo Bianco. 2005. *Using information and communication technologies in adult literacy education: New practices, new challenges*: ERIC (Education Resources Information Center). Institute of Education Sciences.

Social Policy Research Associates. 2013. *PY 2012 WIASRD DataBook*. Oakland, CA.

Spencer, Daniel. 2012. "Flipping." Educational Technology Professional Development for K-12 Educators, Michigan State University.

Stanford-Bowers, Denise E. 2008. "Persistence in online classes: A study of perceptions among community college stakeholders." *Journal of Online Learning and Teaching* 4 (1):37-50.

Sullivan, Felicia M. 2013. "New and Alternative Assessments, Digital Badges, and Civics: An Overview of Emerging Themes and Promising Directions." The Center for Information & Research on Civic Learning & Engagement.

Swars, S L, D W Stinson, and S Lemons-Smith. 2009. Proceedings of the 31st annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Atlanta, GA.

Tabs, E.D. 2003. "Distance Education at Degree-Granting Postsecondary Institutions: 2000-2001. Edited by the Institute of Education Sciences, National Center for Education Statistics, U.S. Department of Education. Washington, DC.

Tamassia, Claudia, Marylou Lennon, Kentaro Yamamoto, and Irwin S Kirsch. 2007. "Adult literacy in America: A first look at results from the Adult Education Program and Learner Surveys."

Taylor, Judy M. 2006. "The effects of a computerized-algebra program on mathematics achievement of college and university freshmen enrolled in a developmental mathematics course." Texas A&M University.

Teplechuk, Evgenia. 2013. "Emergent models of Massive Open Online Courses: An exploration of sustainable practices for MOOC institutions in the context of the launch of MOOCs at the University of Edinburgh."

Tornsaufer, Claudia. 2013. "Comparing Student Retention in On-Campus, Synchronous, and Asynchronous Online Credit Courses at California Community Colleges." San Diego State University.

Uram, Courtney, Diane Wilcox, and Jane Thall. 2010. "Games and Simulations in Training."

U.S. Department of Education. 2014. “Application for New Awards; Center for the Study of Distance Education and Technological Advancements.” *Federal Register* 79, no. 142 (July 24, 2014): 43032.

U.S. Department of Education, Office of Career Technical and Adult Education. *US Department of Education Principal Office Functional Statements*. Available from https://www2.ed.gov/about/offices/list/om/fs_po/ovae/intro.html.

U.S. Department of Education, Office of Educational Technology. 2010. "Transforming American Edication: Learning Powered by Technology." Washington, DC.

U.S. Department of Education, Office of Educational Technology. 2013. “Expanding Evidence Approaches for Learning in a Digital World.” Washington, DC.

U.S. Department of Education, Office of Vocational and Adult Education. 2012. "Investing in America's Future: A Blueprint for Transforming Career and Technical Education."

U.S. Department of Education, Office of Vocational and Adult Education. 2013a. "Adult Education and Family Literacy Act of 1998: Annual Report to Congress Program Year 2010-2011." Washington, DC.

U.S. Department of Education, Office of Vocational and Adult Education. 2013b. "Implementation Guidelines: Measures and Methods for the National Reporting System for Adult Education." Washington, DC.

U.S. Department of Labor. 2008a. Training and Employment Notice No. 17-07. Washington, DC.

U.S. Department of Labor. 2008b. Training and Employment Notice No. 11-08. Washington, DC.

U.S. Department of Labor. 2011. Training and Employment Notice No. 12-11. Washington, DC.

U.S. Department of Labor. 2012. Training and Employment Notice No. 5-12. Washington, DC.

U.S. Department of Labor. 2013a. Notice of Availability of Funds and Solicitation for Grant Applications for Trade Adjustment Assistance Community College and Career Training Grants Program. Washington, DC.

U.S. Department of Labor. 2013b. Request for Quote-Design Study on Technology-Based Learning and Workforce System Services. Washington, DC.

U.S. Department of Labor. 2013c. Training and Employment Notice No. 29-12. Washington, DC.

U.S. Department of Labor, Employment and Training Administration (DOL, ETA). 2014. Accessed September 9, 2014. http://www.doleta.gov/performance/charts/internetassist.cfm

U.S. Government Accountability Office. 2005. "Substantial Funds are Used for Training, but Little is Known Nationally about Training Outcomes." Washington, DC.

U.S. Government Accountability Office. 2013. "New Federal Research Center May Enhance Current Understanding of Developmental Education." Washington, DC.

U.S. President. 2009a. *Remarks by the President on the American Graduation Initiative*. Available from http://www.whitehouse.gov/the_press_office/Remarks-by-the-President-on-the-American-Graduation-Initiative-in-Warren-MI.

U.S. President.2009b. Excerpts of the President's remarks in Warren, Michigan.

U.S. President. 2014a. "Ready to Work: Job-Driven Training and American Opportunity."

U.S. President. 2014b. "What Works in Job Training: A Synthesis of the Evidence."

U.S. President. 2014c. State of the Union Address (September 5). Available from http://www.whitehouse.gov/the-press-office/2014/01/28/president-barack-obamas-state-union-address.

Van Rooij, Shahron Williams. 2007. "Webmail versus webapp: Comparing problem-based learning methods in a business research methods course. "*Journal of Interactive Learning Research* 18 (4):555.

VanLehn, Kurt. 2011. "The relative effectiveness of human tutoring, intelligent tutoring systems, and other tutoring systems." *Educational Psychologist* 46 (4):197-221.

Vassiliou, John. 2011. Improved outcomes with computer-assisted instruction in mathematics and English language skills for Hispanic students in need of remedial education at Miami Dade College, Florida. Community College Journal of Research and Practice 35 (3):191-201.

Vihtonen, Esa, and Eugene Ageenko. 2002. "Viope-computer supported environment for learning programming languages." Paper read at The Proceedings of the International Symposium on Technologies of Information and Communication in Education for Engineering and Industry (TICE2002).

Visser, J., and M. Visser-Valfrey. 2008. *Learners in a Changing Learning Landscape: Reflections from a Dialogue on New Roles and Expectations.* Springer.

Walsh, Lucas, Barbara Lemon, Rosalyn Black, Cheryl Mangan, and Philippa Collin. 2011. "The Role of Technology in Engaging Disengaged Youth," final report.

Wang, Feihong, and Barbara B Lockee. 2010. "Virtual Worlds in Distance Education: A Content Analysis Study." *Quarterly Review of Distance Education* 11 (3):183-186.

Wang, Tsung Juang. 2011. "Educating avatars: on virtual worlds and pedagogical intent." *Teaching in Higher Education* 16 (6):617-628.

Warschauer, Mark, and Meei-Ling Liaw. 2010. "Emerging Technologies in Adult Literacy and Language Education." National Institute for Literacy.

West, Darrell M. 2012. "Big Data for Education: Data Mining, Data Analytics, and Web Dashboards." Governance Studies. at Brookings. US: Reuters.

West, Darrell M. 2012. "Big data for education: Data mining, data analytics, and web dashboards." Governance Studies at Brookings, September. http://www. brookings. edu/~/media/research/files/papers/2012/9/04% 20education% 20tec hnology% 20west/04% 20education% 20technology% 20west. pdf.

Whitton, Nicola. 2012. "The Place of Game-Based Learning in an Age of Austerity." *Electronic Journal of e-Learning* 10 (2):249-256.

Wiecha, John, Robin Heyden, Elliot Sternthal, and Mario Merialdi. 2010. "Learning in a virtual world: experience with using second life for medical education." *Journal of medical Internet research* 12 (1).

Wladis, Claire, Kathleen Offenholley, and Michael George. 2014. "Leveraging Technology to Improve Developmental Mathematics Course Completion: Evaluation of a Large-Scale Intervention." *Community College Journal of Research and Practice* (ahead-of-print):1-14.

Woods Jr., Robert H, and Jason D Baker. 2004. "Interaction and Immediacy in Online Learning." *International Review of Research in Open and Distance Learning* 5 (2).

Workforce Innovation and Opportunity Act. Public Law No. 113-128. 113th Cong.

Xu, Di, and Shanna Smith Jaggars. 2013. "Examining the effectiveness of online learning within a community college system: An instrumental variable approach."

Yang, Jaeseok. 2013. "Mobile Assisted Language Learning: Review of the Recent Applications of Emerging Mobile Technologies." *English Language Teaching* 6 (7).

Yukselturk, Erman. 2010. "An Investigation of Factors Affecting Student Participation Level in an Online Discussion Forum." *The Turkish Online Journal of Educational Technology* 9 (2).

Zhuang, Yuan, and Simon KS Cheung. 2013. "A Case Review on the Implementation of Intelligent Tutoring Systems on Mobile Devices." In *Hybrid Learning and Continuing Education*: Springer.

Zickhur, Kathryn. 2013. "Who’s Not Online and Why." *Pew Research Center, September*.

Appendix A. Documentation of Literature Search Strategy

In accordance with the statement of work and subsequent direction from DOL , Abt Associates prepared a literature review that focused on "the use of technology for training, employment-related education, and access to employment services for key target groups served in the public workforce system" (DOL 2013). To accomplish this, a dual-strategy approach was undertaken to identify relevant literature.

The search involved (1) a traditional keyword search using online resources and (2) a more targeted follow-up investigation that focused on key citations as well as input from key stakeholders including additional search parameters, specific references and resources, and professional contacts. In each case, the results were reviewed for title or abstract relevance then narrowed using filters or inclusion criteria to ensure consistency with the established research question. Finally, the searches were undertaken iteratively such that findings from prior searches contributed to the direction and scope of subsequent searches.

Research Questions

To be included in the review, articles had to address the primary research question: ***What is the recent empirical evidence regarding use of technology-based learning in building work-related skills and increasing employment and earnings?*** Within this primary question are four key topics and sub-questions of interest:

> ***Concepts and technologies.*** What are common or useful frameworks for organizing technology-based learning? Are there key dimensions that characterize and differentiate types of technology-based learning interventions? Are there important emerging models or modes of technology-based learning that are not fully accounted for in these current frameworks?
>
> ***TBL prevalence and use.*** What is known about the current adoption and use of technology-based learning for workforce development? Does this vary across the broad usage and delivery landscape (e.g., public workforce system, the career and technical education system, and private employers)?
>
> ***Considerations in adoption.*** What is known about the major factors that influence the demand for and adoption of technology-based learning for workforce development?
>
> ***Evidence of effectiveness.*** What is the empirical evidence of the effectiveness of particular technology-based learning programs for improving workforce-related outcomes?

Search Strategy 1: Keyword Search

Resources and Materials

The research team consulted both traditional research resources (e.g., academic libraries, journal searches, Google Scholar and Google) as well as well as subject matter experts (e.g., project Technical Work Group members, DOL representatives) to identify prospective resources. The following databases, journals, and websites were ultimately searched:

Databases.

- Association for the Advancement of Sustainability in Higher Education (AASHE)
- Academic OneFile
- EBSCO (includes Academic Search Complete, Business Source Corporate, EconLit, SocINDEX with Full Text)
- EdITLib
- Education Resources Information Center (ERIC)
- ETA Research Publication Database
- Interuniversity Consortium for Political and Social Research (ICPSR)
- JSTOR
- LexisNexis Academic
- ProQuest Dissertations & Theses
- ProQuest Research
- National Bureau of Economic Research (NBER)
- PsycINFO
- Science Direct
- WorldCat

Journals.

- Adult Basic Education
- Adult Basic Education & Literacy Journal
- Adult Education Quarterly
- Advances in Developing Human Resources
- The American Journal of Distance Education
- American Journal of Education
- British Journal of Educational Technology
- Community College Journal of Research and Practice
- Computers & Education
- International Conference on Education Technology and Computer (ICETC)
- Educational Technology Research & Development
- Educational Technology & Society
- Edutech Report

- International Journal Of Mathematical Education In Science And Technology
- International Journal of Mobile & Blended Learning
- The Internet and Higher Education
- Journal of Asynchronous Learning Networks
- Journal of Computer Assisted Learning
- Journal of Educational Technology & Society
- Journal of Interactive Online Learning
- Journal of Online Learning and Teaching
- Journal of Literacy and Technology
- Journal of Research & Practice for Adult Literacy, Secondary & Basic Education
- Journal of Research on Technology in Education (JRTE)
- Journal of Science Education and Technology
- New Directions for Adult & Continuing Education
- THE Journal: Technological Horizons In Education

Websites.

- Abt Associates (http://www.abtassociates.com/)
- Center for the Analysis of Postsecondary Readiness (http://ccrc.tc.columbia.edu/research-project/center-analysis-postsecondary-readiness.html)
- Center for the Study of Adult Literacy (http://csal.gsu.edu/)
- MDRC (http://www.mdrc.org/)
- New Media Consortium, Horizon Project: http://www.nmc.org/horizon-project
- Pew Research Internet Project: http://www.pewinternet.org/

Key Terms and Phrases

Key terms and phrases that were used in the initial overview literature search served to identify general topical relevance (i.e., relevance to the primary research question). This "base set" of terms and phrases is organized around two broad parameters: (1) technology-based learning and (2) the workforce development context and population.

Base set of terms and phrases to identify general topical relevance[46]

Technology-based learning. Asynchron*, blended, computer-assisted instruction, computer-aided, e-learning, eLearning, face-to-face, facilitate interaction, online education, online learning,

[46] Asterisks indicate a set of search terms with a common root. For example, "Asynchron*" includes the terms "asynchrony", "asynchronous", and "asynchronously".

online training, student-centered content, student-centered, synchronous*, technology-assisted, technology-based, virtual classroom, web-based

The workforce development context and population. Adult basic education (ABE),adult basic literacy, adult education, adult literacy, adult secondary education (ASE), adult training, AJC, American Job Centers, andragog*, at-risk, career and technical education (CTE), developmental, disabled, disadvantaged, dislocated, displaced, English as a Second Language (ESL), English Language Learners (ELL), General Educational Development (GED), low-income, low-skill, occupational education, occupational training, remedial, remediated, undereducated, unemployed, vocational education, vocational training, WIA Title, workforce development, workforce preparation, workforce training

Excluding or filtering. Child*, elementary, high school, K-12, medic*, middle, primary, postsecondary, secondary, university

Key terms or phrases within each category were combined using the OR operator to expand the search and capture articles with different variations of a term. The last category of words were included using the NOT operator to filter out articles that were not topically relevant. Additionally, searches were customized for each topic or sub-question to increase precision. Terms from the base set were combined with the topic/sub-question-specific terms using the AND operator to increase topical precision.

Concepts and technologies. Adaptive learning, adaptive software, avatar, big data, competency-based, cloud, data driven instruction, digital badges, digital games, digital transcripts, digital tutor, e-portfolio, educational data mining, emerging, flip* the classroom, flipped classroom, framework, game-based learning, gamification, simulation, immersive simulation, intelligent tutor, learning analytics, mobile, mobile learning, MOOC, new technolog*, OER, Open Educational Resources, overview, social learning, social media technolog*, U-pace instructional method, virtual classroom, virtual world*

Prevalence and use**.** Attrition, census, employers, engagement, extent, extent of technology integration, frequency, incidence, occurrence, participation, pervasiveness, popularity, prevalen*, producer*, provide*, survey, sample, usage rates, widespread

Considerations in adoption. Barriers, consider*, correlat*, cost*, demand, factor*, outcome*, pre-post, public policy, relate*, relationship, motivation, engagement, social presence, technological access, technology acceptance

Evidence of effectiveness**.** Attrition, baseline, comparison group, control group, counterfactual, earning, effect*, effic*, employment status, engagement, equivalen*, evidence, experiment*, impact, non-experiment*, participation, pre-test/post-test, pretest/posttest, quasi-experimental design (QED), random assign*, randomized control trial (RCT), regression discontinuity design (RDD), retention, rigor*, sample, satisfaction, score, test, wage

Search Strategy 2: Targeted Searches

Two-part Citation Search

To identify additional articles and to increase the depth of the literature in each of the four categories, a citation or reference search was conducted in two parts. The first part, commonly referred to as a "snowball" search, is a "backwards" search through citations: relevant citations in each base article were identified, then relevant citations referenced in those cited articles were identified, and so on. The second part is a "forward" search through citations. Google Scholar's "cited by" feature was utilized to identify additional and more recent articles that cited the base article.

Stakeholder and Expert Recommendations

Finally, suggestions from DOL, other federal stakeholders, and a technical working group of experts led to the identification of a number of studies, articles, journals, and websites. These were then subjected to the two-part citation search referenced above.

Inclusion Criteria

Articles had to be written in English and had to come from an academic journal, conference, or report, to be included in this review. Recent articles (within the last ten years, unless otherwise specified) were privileged, but seminal articles were also accepted. First, the titles and abstracts of these articles were reviewed for topical relevance. Then, the full text was subject to any additional inclusion criteria. Each area of research had a slightly adapted set of criteria, as reflected in the search terms above.

Criteria for Concepts, Strengths, and Limitations

Articles contributing to an overview of the literature, as well as articles from the other three areas of research, had to focus on technology-based learning in a workforce development context or with populations comparable to those served by the workforce development system.

Criteria for Considerations for Using and Providing TBL

Recent non-experimental or correlational empirical studies of the (potential) determinants of course completion, service utilization, and engagement among learners in community college or other workforce development settings; surveys of relevant training and education providers and employers on factors affecting the adoption of TBL; and articles or reports on recent TBL-related initiatives and policies from the public sector.

Criteria for TBL in Workforce Training and Education

Surveys of TBL utilization by providers of workforce training and education in the United States were included. Selection emphasized results published within the last ten years, but older results were included to the extent that they allowed for historic or longitudinal comparisons to recent results.

Criteria for Empirical Evidence on the Use of TBL

Finally, studies of the effectiveness of TBL were subject to the following set of criteria: the study design had to use a comparison group. This included randomized control trials (RCTs), regression discontinuity designs (RDDs), and quasi-experimental designs (QEDs). The study also had to use, as metrics, workforce-related outcomes: behavioral metrics, perceptual or satisfaction data, learning outcomes (e.g., test scores), or workforce outcomes (e.g., employment, earnings, job retention). Correlational, outcomes only studies were not included, nor were descriptive or case studies.

Criteria for Recent and Emerging Trends

Articles identifying emerging technologies, had to have been published after January 2005 to be initially reviewed, but only those articles published after 2009 were included in the report. Criteria for classifying emerging technologies were not clear cut. Approximately, only technologies at the cutting edge of education in the last decade were considered emerging. These included adaptive software and other data-driven technologies, mobile, open educational resources and other content sharing technologies, simulations, social media software, and virtual worlds. On the other hand, older technologies such as two-way video conferencing, e-mail and other asynchronous chat-based software, power point and similar visual content display technologies were excluded.