THE EFFECTS OF TECHNICAL TRAINING DESIGN ON TRAINEE'S SKILLS, KNOWLEDGE ACQUISITION AND TRANSFER TO JOB PERFORMANCE: THE CASE OF TURKISH AEROSPACE

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submitted by **EMRE YILMAZ** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Computer Education and Instructional Technology, Middle East Technical University** by,

Prof. Dr. Halil Kalıpçılar

Dean, Graduate School of **Natural and Applied Sciences**

Dr. Hasan Karaaslan

Head of the Department, **Comp. Edu. and Inst. Tech.**

Prof. Dr. Soner Yıldırım

Supervisor, **Comp. Edu. and Inst. Tech., METU**

Examining Committee Members:

Prof. Dr. Ömer Delialioğlu

Comp. Edu. and Inst. Tech., METU

Prof. Dr. Soner Yıldırım

Comp. Edu. and Inst. Tech., METU

Prof. Dr. Yasemin Gülbahar

Comp. Edu. and Inst. Tech., Ankara University

Prof. Dr. Halil Yurdugül

Comp. Edu. and Inst. Tech., Hacettepe University

Assoc. Prof. Dr. Yeşim Çapa Aydın

Department of Educational Sciences., METU

Date: 09.09.2021

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Lastname: Emre Yılmaz

Signature:

ABSTRACT

THE EFFECTS OF TECHNICAL TRAINING DESIGN ON TRAINEE'S SKILLS, KNOWLEDGE ACQUISITION AND TRANSFER TO JOB PERFORMANCE: THE CASE OF TURKISH AEROSPACE

Yılmaz, Emre
Doctor of Philosophy, Computer Education and Instructional Technology
Supervisor: Prof. Dr. Soner Yıldırım

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From the organizational development perspective, training is a vital instrument for improving operational capabilities and adapting to changing needs of the time. The present study aims to investigate the effects of a systematic and structured training design approach on trainee's skills, knowledge acquisition, and far transfer. For that purpose, Clark's technical training development framework was interpreted and a guidance matrix was devised for the specific case of Turkish Aerospace. In the course of the study, a particular training within the curricula of the Turkish Aerospace Academy was selected and redesigned according to the proposed matrix by collaborating with a subject matter expert. The study followed an experimental research design to examine the effect of the proposed approach. A total of 120 participants were split in half and randomly assigned to treatment and control groups. The control group participated in the original course whereas the treatment group was exposed to the redesigned course. Kirkpatrick's training evaluation model was followed to explain the effects of the proposed training design approach for different levels of impact. Participants took a pretest exam before the course and also took a posttest exam upon completing the course. All participants also filled a reaction questionnaire after the course. In addition, operational error counts of the participants before and after the course were recorded to observe their job performance. Data analyses were carried out to reveal the effect of the redesigned course on learning, reaction, and transfer results. Analyses showed that the treatment yielded an increased posttest score and a decreased number of errors while holding pre-course exam scores and error counts constant. Also, the treatment group reported better reactions in terms of training objectives, content, and evaluation method. The study provided an interpretation of Clark's content-performance matrix that is shown to be effective in designing technical training within the aerospace industry context.

Keywords: Technical Training, Instructional Design, Training Design, Training Evaluation, Transfer of Learning

ÖZ

TEKNİK EĞİTİM TASARIMININ, ÖĞRENENİN YETENEKLERİ, BİLGİ KAZANIMI VE İŞ PERFORMANSINA TRANSFER ÜZERİNDEKİ ETKİLERİ: TÜRK HAVACILIK VE UZAY SANAYİİ ÖRNEĞİ

Yılmaz, Emre
Doktora, Bilgisayar ve Öğretim Teknolojileri Eğitimi
Tez Yöneticisi: Prof. Dr. Soner Yıldırım

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Organizasyonel gelişim açısından bakıldığında iş yeri eğitimleri, operasyonel yetenekleri geliştirmek ve değişen şartlara uyum sağlamak konusunda oldukça önemli bir araçtır. Bu çalışma, sistematik ve yapılandırılmış bir eğitim tasarımı yaklaşımının katılımcının becerileri, bilgi edinimi ve uzak transfer düzeyleri üzerindeki etkilerini araştırmayı amaçlamaktadır. Bu amaçla, Clark'ın teknik eğitim geliştirme yaklaşımı yorumlandı ve Türk Havacılık ve Uzay Sanayii (TUSAŞ) örneği için bir kılavuz matris oluşturuldu. Çalışma sırasında, TUSAŞ Akademi müfredatında yer alan bir teknik eğitim seçildi ve bir konu uzmanı ile işbirliği içinde, önerilen matrise göre yeniden tasarlandı. Önerilen yaklaşımın etkisini incelemek için deneysel araştırma deseni kullanıldı. 120 katılımcı ikiye bölünerek deney ve kontrol gruplarına rastgele biçimde atandı. Kontrol grubu, seçilen dersin orijinal versiyonuna katılırken deney grubu ise aynı dersin yeniden tasarlanmış versiyonunu aldı. Önerilen eğitim tasarımı yaklaşımının farklı seviyelerdeki etkilerini anlamak için

Kirkpatrick'in eğitim değerlendirme modeli kullanıldı. Gruplar, ders öncesi ön test sınavına ve dersi tamamladıktan sonra ise son test sınavına girdiler. Tüm katılımcılar ayrıca dersten sonra bir reaksiyon anketi doldurdu. Ek olarak, katılımcıların iş performanslarını inceleyebilmek adına, ders öncesi ve sonrası operasyonel hata sayıları kayıt altına alındı. Öğrenme, reaksiyon ve transfer durumlarına yönelik veri analizleri yapıldı. Analizler, önerilen eğitim tasarımının, ders öncesi koşulların etkisi ayrıştırıldığında, son test puanında artış ve hata sayısında azalma sağladığını gösterdi. Ayrıca deney grubu, eğitim hedefleri, içerik ve değerlendirme yöntemi açısından dersle ilgili daha iyi tepkiler bildirdi. Bu çalışma ile, Clark'ın içerik-performans matrisinin, havacılık ve uzay sektörün bağlamında, teknik eğitim tasarımı açısından etkili sonuçlar verdiği gösterilmiş bir uyarlaması üretilmiştir.

Anahtar Kelimeler: Teknik Eğitim, Öğretim Tasarımı, İş Yeri Eğitimi Tasarımı, Eğitim Değerlendirmesi, Öğrenmenin Transferi

Ars longa, vita brevis, occasio praeceps, experimentum periculosum, iudicium difficile. (Hippocrates)

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LIST OF ABBREVIATIONS

4C/ID: Four-Component Instructional Design

ATD: Association for Talent Development

CBT: Computer-Based Training

CDT: Component Display Theory

CVI: Content Validity Index

CVR: Content Validity Ratio

ERP: Enterprise Resource Planning

ISD: Instructional Systems Design

KPI: Key Performance Indicator

LTEM: Learning-Transfer Evaluation Model

NCR: Non-Conformity Report

OJT: On-The-Job Training

ROE: Return On Expectations

ROI: Return-On-Investment

TAI: Turkish Aerospace Inc.

CHAPTER 1

INTRODUCTION

This chapter of the dissertation presents the rationale underlying the study. It is comprised of the background of the study, statement of the problem, the purpose of the study, the significance of the study, research questions, and definition of terms.

1.1 Background of the Study

Training and development of the workforce have always been a major concern for different types of organizations throughout history. Human Capital Theory, the seminal work of Gary Becker, is a huge milestone in that perspective as it completely changed the way how education and training activities were perceived by organizations. Becker's (1964) theory suggests that ability of learning has the potential to provide value to organizations similar to the other resources utilized in the production of goods or services. Becker won the Nobel Prize in economics in 1992 with his work (The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred NOBEL 1992, n.d.) and paved the way for large-scale endeavors and investments in the field.

What begins as an effort to provide workers with the means for acquiring necessary skills has extended and transformed into a systematic approach for talent management within an organization. Among many factors driving the transformation of training activities, the rise and expansion of knowledge work across all fields and professions have arguably been the most influential one (World Bank, 2003, p. 3).

Many thinkers or leaders predicted that a dramatic change in the creation of added value is about to occur at the turn of the century. Drucker (1988), one of the earliest to mention it, suggested that "the center of gravity in employment" will rapidly shift from "manual and clerical workers" to knowledge workers who won't comply with the strictly structured and hierarchical model of organizational operations borrowed from the military tradition. The landscape of business and organizational activities in the 21st century seems significantly different from what has been the norm in the 20th century (Toffler, 1980). The dramatic change in recruitment and competition strategies laid the foundations for recalibrating the role of training within organizational development (Fitzpayne & Pollack, 2018).

In the age of automation, division of labor and mass production, organizations primarily aimed to find and hire top talents in specific disciplines to grow and compete in their fields. However, that was no longer the case in the age of digitalization and autonomous decision-making. It has become insufficient to have the top talent hired to stay competitive (Urdan & Weggen, 2000, p. 2). Organizations are required to keep their competencies improved matching the pace of dynamic change and innovation in every industry (van Weert, 2005, pp16-17; Biech, 2014, p. 889). Otherwise, it has become unlikely to have a comparative advantage against their rivals or to meet the swiftly evolving needs and expectations of their clients (Aguinis & Kriager, 2009).

The value of training is not limited to its contribution to organizational competency and development. As global economies lean towards the knowledge society, another theme has emerged. Numerous studies consistently confirmed that quality and diversity of training opportunities within an organization is likely to increase employee commitment, loyalty and job satisfaction (Saks, 1995; Bartlett, 2001; Tansky & Cohen, 2001; Lowry & Kimberley, 2002; Schmidt, 2010). Because the emphasis and resources placed on training are perceived as an indicator of how much they are valued by the employees (Schmidt, 2004 as cited in Schmidt, 2010).

Accordingly, the emphasis placed on training activities has gradually increased and eventually, training has turned into a strategical dimension of organizational development instead of a tactical or operational one. The creation of Chief Learning Officer (CLO) positions at numerous organizations, generally large ones, is a great indicator of that new strategic role associated with training activities. According to a recent report, the percentage of executives who agree that CLO positions must be a part of so-called “C-Suite” –highest order strategic administrative positions directly reporting to the top manager – recorded a dramatic leap from 24% to 63% in a single year concerning the extraordinary conditions stemmed from the global COVID-19 outbreak (Linkedin Learning, 2021).

Apart from the shift towards the knowledge workers in the employment market, training activities are already based on solid foundations. The concept of training exists because the knowledge and skills in every workplace have particular and implicit components which are not likely to be provided in formal education (Fischer, 2000). In addition, it is important to notice that necessary skillsets in the workplace are called “competencies” with respect to highly dynamic nature of work-related methodologies and technologies. Employees are expected to compete with themselves and their peers to stay up-to-date whereas students in formal learning are typically expected to achieve mastery in a pre-determined curriculum. That critical difference ensures that the concept of training takes its place as an inevitable component in the philosophy of lifelong learning (Phillips, 2010, p. vii).

On the other hand, training activities have inherent and chronic problems to overcome. The first of two major challenges is what Patricia Crull, a chief learning officer, calls “measurement and evaluation dilemma” (P. P. Phillips, 2010). Although most executives recognize the training activities as valuable and necessary parts of development, they tend to question the existence of training programs easily in case of insufficient evidence showing the impact (Cepeda, Vul, Rohrer, Wixted & Pashler, 2008; Soderstrom, Kerr & Bjork, 2016). Rhetorical support for training is often not materialized or not permanent in practice within many organizations. Therefore, the ability to present findings, factual arguments or indicators is critical to justify the strategic value of training. However, measuring and determining the impact of training is a formidable challenge that requires expertise and time.

The second major challenge regarding training activities is the design and implementation limitations that are inherent to the workplace. For instance, temporal spacing and rehearsals are essential for any kind of learning occurrences (Blumenfeld, Kempler & Krajcik, 2012, pp. 475-487). But time is also a precious resource in the workplace that is primarily needed to be dedicated to the work itself rather than the training. Similarly, motivation and engagement are crucial conditions for learning (J. D. Kirkpatrick & Kirkpatrick, 2016). In workplace settings, the principal concern for employees is their job which makes training activities secondary objectives almost all the time. Consequently, instructional design for the workplace settings necessitates careful analyses and proficiency in learning sciences to address such kinds of limitations but those qualifications are not available most of the time.

In the course of transformation from skills training to a strategic function of talent management, design and evaluation have remained the key to either success or failure of any training program (Carliner, 2015, p. 4). Training programs take place in professional life and thereby they are subject to expectations from a business point of view. Evaluation methods help demonstrating the value created through instructional activities and thence justify the investments in training. But before showing the value, it must be produced in the first place as Kirkpatrick & Kirkpatrick (2016) state. Training design plays a substantial role in providing value for organizations since it refers to the activities ensuring the alignment between training objectives and bottom-line business goals (Gustafson & Branch, 2002b).

Design and evaluation stages, two typical components of almost any instructional design model (Becker, 1964), are evidently important to pose a business case for training. For this reason, the present study focuses on them in a particular domain.

1.2 Statement of the Problem

The Human Capital Theory (Aliaga, 2001), which attempts to explain the outputs of training activities as a form of investment (Fenwick, 2008b), has been highly influential in shaping the profession of training. Resources allocated to training have been consistently increasing since the emergence of the concepts like "human capital" or "intellectual capital". Global workplace training expenditures reached an estimated size of 370.3 billion USD in 2019 (Statista, 2020) and they are projected to hit 417.2 billion USD by 2027 (Priya, 2020).

The investment-oriented approach to training is well-aligned with the acquisitive perspective of workplace learning (Nafukho, Hairston & Brooks, 2004). Therefore, the assumption that learning is an individual process of acquiring and storing new knowledge or skills which will then translate into organizational capabilities has been widely accepted within the training community (Fenwick, 2008a). This belief has been in decline since the mid-1980s though (Fenwick, 2008b). Main problem of that approach is that it treats knowledge or skills like packages that remain unchanged in the course of transfer from source to the receiver (Fenwick, 2008a). However, a plethora of evidence from the literature indicates that learning is much more than a straightforward data transfer process. Although many different interpretations of the learning process are present (Schuell, 1986), one common theme across all theories is that learning is an action of the learner, not the other way around (Biech, 2014).

In elaboration of relevant literature, three main views of learning can be briefly explained as follows. First of all, behaviorist exposition of learning relies on the establishment of associations between stimulus and responses (Thorndike, 1913) which must be carried out by the learner. Secondly, cognitivist exposition of learning is comprised of cognitive mechanisms working together to process, store and organize the information (Atkinson & Shiffrin, 1968; Gagne, Briggs & Wager, 1992) and apparently, those mechanisms are learner's mental tools. Lastly, the constructivist exposition of learning is based on the proposition that the learner constructs meaning out of his/her experiences and interactions with the environment (Bruner, 1964). Therefore, it can be inferred that learning is about the learner's internal processes and there is not any dispute over that.

On the other hand, there is a substantial discrepancy between well-established literature of learning sciences and widespread assumptions or practices within the training community (Clark, 2019, p. 6). The gap between research and practice is so significant that it can form a common misunderstanding that ignores a fundamental fact as explained above. One factor regarding the development of ineffective practices is the investment perspective towards training and workplace learning which promotes an intensively results-oriented approach. Extreme focus on outputs and return on investment encourage training designers and managers to neglect theoretical knowledge of instructional design and learning sciences, instead, they are typically occupied with seeking out practical means to deliver training. Another factor in play is the profile of training practitioners. Even if organizations are aware of the importance of evidence-based training activities, they might lack the human resources to utilize the theoretical knowledge. As a matter of fact, interpreting and implementing instructional design and evaluation models require a firm background in learning sciences. Hence, training activities are often performed by “occasional trainers” who are not instructional experts but competent specialists in a particular task or topic (Stolovitch & Keeps, 2014). Since most of the relevant literature is descriptive in nature, workplace trainers have difficulties in interpreting and applying it.

In the conclusion, hindrance from investment-oriented approach over training design, widespread acceptance of acquisitive perspective of learning and the fact that training activities heavily rely on occasional trainers have a combined negative effect on common training practices. This effect prevents training efforts from producing transferable learning outcomes and thus weakens the beliefs of executives and stakeholders within the organizations that training is a justifiable tool for creating value (Stolovitch & Keeps, 2004).

The effect is even more prevalent in the field of technical training. Because the majority of models and methods used in workplace learning are borrowed from formal learning environments where learning objectives in the cognitive domain are typically the primary focus. However, technical training activities are mostly conducted to achieve psychomotor domain objectives. Providing that psychomotor objectives are inherently more tangible and observable, the expectation to see an impact from technical training is stronger compared to other types of training activities. As a result, organizations tend to question the utility of technical training activities in a sharper way.

1.3 Purpose of the Study

Problematic expectations and perceptions towards training are main concerns for this research. Accordingly, the current study aims to present a training design guideline that addresses essential issues in the field of technical training as explained in the previous section.

First and foremost, this study is dedicated to provide a prescriptive instructional design tool that is straightforward and practical enough to be implemented by both occasional trainers and instructional experts in the workplace settings. For this purpose, Clark's (2011) technical training design guide is adopted and interpreted in a certain context. The second purpose of the study is to demonstrate an evidence-based instructional design approach which will then be utilized to improve the course design quality for a catalog of technical training within the same context. Finally, the present study intends to yield a working example on how to evaluate technical training effectiveness and thence showing the value created by workplace learning.

The overall aim of this research effort can be summarized as producing a practical technical training design tool based on instructional principles with demonstrated impact on business objectives.

1.4 Significance of the Study

The present study is motivated by authentic challenges from a certain corporate academy and it seeks to help filling the gap between literature and practice. Correspondingly, this research aims to make contributions to the field of technical training in many aspects.

Firstly, issues in training design practices are among main questions addressed in this work. A considerable amount of literature has been published on instructional design and development which also translates into the field of training design. These studies suggested various instructional design models which tend to highlight either process or function. For instance, Smith & Ragan's (2005) perspective emphasizes the process since it defines instructional design as a systemic process of interpreting and reflecting instructional principles into plans for materials, activities or resources. On the other hand, Reigeluth's (1983) approach to instructional design is function-oriented because he describes it as the collection of knowledge prescribing instructional activities to achieve desired outcomes in an optimized way. Latter viewpoint towards instructional design lends itself better to training design considering the reliance on occasional trainers in practice and inherently high importance placed on the alignment between outcomes and business expectations. Such kind of function-oriented explanations were also suggested by other researchers as well (Piskurich, 2006; Gustafson & Branch, 2007). Even though this perspective is reflected in certain instructional models, instructional designers still need to interpret and modify generic models to accommodate their context. Analyzing the context in terms of factors and limitations that are likely to influence training activities and adapting the design models based on those inferences require expertise in the field of instructional design and learning sciences. Several studies have revealed that the way instructional design models are interpreted varies based on the expertise level of the designer (Rowland, 1993; Perez & Emery, 1995). However, as in the context of this study, occasional trainers are vital for training operations within large organizations which has a vast and diverse body of knowledge to teach. Occasional trainers are not experts but people with particular know-how who find themselves in the role of an instructor or trainer every now and then (Stolovitch & Keeps, 2020). Therefore, the extent to which existing models can be transformed into practice is limited by the expertise and capabilities of the available workforce typically dedicated to training activities, especially in the context of large-scale organizations. The current study addresses that gap in the literature by attempting to devise an exemplary guide that is as prescriptive and undemanding as possible to lower the level of expertise to design a technical course. Thereby, it is aimed to make the wisdom embedded in instructional design models more comprehensible and applicable for subject-matter experts or occasional trainers which is likely to facilitate more transferable learning instances.

Secondly, the current study is an effort to promote evidence-based instructional design in the training community. Although many researchers acknowledge that instructional design and development models must be subject to systematic validation in real-life cases (Gustafson & Branch, 2002a), evidence-based design or model examination studies fail to become a top priority in research agendas (Richey, 2005). There is a significant discrepancy between the scientific literature of workplace learning and widespread beliefs or typical prevalent practices in the training community. Both in the design stage (Clark, 2019) and the evaluation stage (J. D. Kirkpatrick & Kirkpatrick, 2016), various misconceptions have been repeatedly adopted. Brinkerhoff (2014) points out that training programs deliver a low rate of success on average with respect to observable and valuable impact on organizational objectives. The consequences of ineffective training are twofold; a) the loss of the investment made on the training event b) the cost of the work hours spent and the cost of the lost opportunity to increase the performance of trainees (Clark, 2011). Jeopardized outcome of training events is closely related to the aforementioned discrepancy which is boosted by the very nature of workplace and business settings.

Unlike formal education, decision-makers in the workplace do not necessarily have a background in the field of education and they are less critical towards proposed methods, materials or human capital for learning-related activities. The training itself is a rapidly growing market (Priya, 2020) and plenty of players keep promoting their products or services for training operations. Although the nature and methods of instruction do not change with high pace, profit-oriented training services need to deliver “new” and “upgraded” products periodically in order to survive in the growth-based economy of today’s world (R. Smith, 2010). Organizations are keen to invest in new instructional technologies or adopt new training methodologies in order to comply with their rhetorical support for learning and development which is important for both their public images and employer brands. The vast amount of supply and justifiable demand give rise to the allocation of abundant resources for training purposes and thence waste of them. Beliefs and practices with no scientific foundations can thrive and spread within the training community with help of an ample and stable stream of resources. Another overlooked consequence of ineffective training practices is the damage to the perception of training in the eyes of executives who, in time, get inclined to see training as a public relations material rather than a strategic tool for organizational development.

This thesis is expected to draw attention to evidence-based instructional design in the workplace by demonstrating a working example that can be applied to a large catalog of similar technical courses sharing the same context. In this respect, it can be qualified as an external model validation effort since it focuses on the effects of using the model instead of concerning the internal consistency of the model (Richey, 2005).

The third and last aspect of the contribution for this work is related to issues in training evaluation. Essential demand for observing the impact of training is even amplified in the case of technical training programs. Because the measurement and evaluation of soft skills are admittedly challenging whereas technical training is characterized as more convenient for providing tangible and quantifiable outcomes (Twitchell, Horton & Trott Jr., 2000). Therefore, the present study focuses on the field of technical training to emphasize the key role of evaluation in workplace settings.

The practice of evaluation for technical training activities is not as common as anticipated, albeit the field is regarded assessment-friendly (Twitchell, 1997; R. C. Williams & Nafukho, 2015). In addition, the majority of training evaluation efforts fail to reach consideration of transfer-level outcomes (ASTD, 2009). Data from several sources have identified most frequently reported reasons for not conducting higher-level training evaluation such as troubles in collecting required data, the difficulty of isolating the impact of training from that of irrelevant factors or not being cost-effective (SHRM, 2005; ASTD, 2009; Giangreco, Carugati & Sebastiano, 2010). This study puts forward a sample technical training design process where transfer-level evaluation is considered beforehand. Thus, it can be taken as an example of how to overcome typical barriers in evaluation processes.

In the course of the study, a technical training design guide is formed which can serve as a decision support tool with clear directives. The guide is in a walkthrough fashion in order to enable occasional trainers and subject-matter experts to design courses with little to no help from professional instructional designers. Furthermore, the study includes a detailed implementation instance which can help prospective users of the guide to make sense of each step. Finally, the present study is an example of applied research (Gay, Mills & Airasian, 2011, p. 17) and accordingly applies an existing guideline to solve practical problems. Findings from this study can be a measure of the usefulness of Clark's (2011) guideline in the context of the Turkish Aerospace industry and, to some extent, other industrial contexts with similar settings.

1.5 Research Questions

In compliance with the purpose of the study, the following research questions are addressed:

1. Does the redesigned course increase post-test achievement scores after adjusting for pre-test achievement scores?
2. Is there a significant difference between the groups in terms of error counts recorded after the course while holding the error counts recorded before the course constant?
3. What is the effect of the redesigned course on trainees' reactions towards training in terms of objectives, content and evaluation aspects?

1.6 Definition of Terms

Fastener: An umbrella term for various elements used in the aerospace industry which are utilized to assemble two or more structural parts in a fixed position.

Instructional Systems Design: ISD is a collection of procedures for designing coherent and dependable education and training programs (Gustafson & Branch, 2002b).

Job Instruction Training: A particular program carried out during World War I which involves training work supervisors as trainers in order to teach job-related skills to the masses in an efficient way (Oakes, 2014).

Key Performance Indicator: A quantifiable or qualitative measure that allows businesses to assess their success in accomplishing strategic and operational objectives (Bishop, 2018).

Non-Conformity Report: A document that indicates a particular operation fails to satisfy the quality criteria in aerospace manufacturing or assembly processes.

Occasional Trainer: People who are asked to design and/or implement training activities for being competent in that particular field. They do not have a background in learning sciences and they are not necessarily a full-time member of the training team of the organization (Stolovitch & Keeps, 2014).

On-The-Job Training: A form of one-to-one interaction where an expert in a particular field demonstrates and teaches an inexperienced peer how to carry out certain tasks (Sleight, 1993).

Return-On-Investment: A metric calculated to reveal the efficiency and profitability of a particular investment (Phillips & Phillips, 2014).

Return On Expectations: A measure of to what extent the expectations of organizational stakeholders are met by a training program (Kirkpatrcik & Kirkpatrick, 2014).

CHAPTER 2

LITERATURE REVIEW

This chapter of the dissertation presents a review of the existing body of knowledge in limits of the fundamental concepts and theoretical foundations concerned in this study.

2.1 What Is Training?

Although it is a frequently used term both in academic literature and in everyday language, a generally accepted definition of training is lacking. Certain themes are commonly used by different definition attempts though.

Goldstein (1991) asserts that training is the systematic conduct of instruction aimed to enable transfer in work organizations. In a narrower perspective, Truelove (1992) describes the training as an effort of transmitting knowledge, skills or attitudes required to perform job-related tasks for improving performance. Wills (1994) follows a slightly different approach by excluding attitudes and defines training as the transfer of determined and measurable knowledge or skills. A broader portrayal of the term transcends to the informal settings by suggesting that training is any kind of activity or course that helps the trainee to acquire job-related knowledge or skills in either formal or informal settings (McLeod, Hare & King, 1996 as cited in Masadeh, 2012).

More definitions from various sources can also be added to the list. But it is evident that three characteristics are included in most of the definitions: a) knowledge and skill acquisition b) being systematic and c) being relevant to a particular job. It can be concluded that the term training typically refers to structured instructional events focusing on the necessary set of skills or knowledge for specific tasks executed in the workplace. This brief definition of the term "training" derived from relevant literature will be used throughout this dissertation.

2.1.1 Historical Development of Training

The ability to learn is a literally vital skill for human beings since it enables us to sustain an accumulative development over generations. That is simply how we managed to survive and dominate the whole planet as a species. Training as a profession of facilitating learning for particular purposes has its roots deep in the beginning of history. One can argue that elders in a community teaching the young how to make tools, take shelter, grow crops or forging iron can be classified as the earliest examples of training (Steinmetz, 1976, pp. 1-3). With that perspective, the historical background of the training profession is a complex and long story. Nevertheless, the subject will be elaborated on a limited scale in this section in accordance with the focus of this dissertation.

On-The-Job Training

The evolution of the training profession can be depicted as a long journey that has started as teaching skills, then focusing on individual development, moving forward to organizational development and centered around systems theory, and eventually integrated with the talent management concept (Oakes, 2014). Sleight (1993) puts forward that on-the-job training was the earliest form of training and it is still popular in the modern world as well. Because it is not complicated and more importantly has a built-in solution to the problem of transfer. The learner is trained in the authentic practice environment and hence has the minimum amount of difficulty in making sense of how to apply what is learned to the work (Sleight, 1993). On the other hand, the method has disadvantages such as rendering experienced peers less productive due to their time spent on training, being hard to scale across large organizations and the fact that not every expert is a necessarily great teacher (Oakes, 2014). Another form of training, apprenticeship, emerged addressing some of these drawbacks. In contrast to the informal nature of on-the-job training, apprenticeship is a relatively formal arrangement which gained popularity when crafts and occupations became too complex to train in a short period of time through on-the-job training (Sleight, 1993). Apprenticeships typically last for years and involve learning to adapt to different possible cases in a field instead of training on particular tasks (Patterson, 1942 as cited in Sleight, 1993).

The Classroom: Factory Schools and Vestibule Training

In time, classrooms have become the customary context of training in line with the economic and social transformation created by the industrial revolution in the 19th century. According to Miller (2008), vocational and manual schools were the earliest form of classroom-based training activities in that era. Those kinds of schools were designed to provide training in specific job-related skills. Subsequently, factory schools were opened which is based on an innovative idea for that time, which was, embedding the classroom into the factory and following a curriculum covering the tasks applied in the nearby workplace (Oakes, 2014). By that time, traditional training methods like apprenticeships were not fast enough to train workers demanded in a factory which serializes its production. Similarly, on-the-job training was not convenient for training a large number of workers at a time which was needed for growing businesses of the era (Smith, 1942 as cited in Sleight, 1993; Steinmetz, 1976). An essential advantage of the classroom compared to apprenticeship or OJT was the fact that it was possible to train a large number of trainees in a rapid fashion with fewer experts. This characteristic of the new model lent itself well to industrialization which calls for plenty of workers trained in certain tasks in order to utilize new machinery to produce goods at an unprecedented rate (Oakes, 2014).

Nonetheless, factory schools had two significant drawbacks. Firstly, in this new form, learning was distanced away from the authentic task environment and therefore learners are required to retain what they are taught until they get the opportunity to apply it in the actual workplace (Sleight, 1993). This was arguably the start of the transfer of the learning issue in the training practices. The second downside of classrooms was the fact that trainees did not have control over their learning pace and they also had limited interaction with the instructor in contrast to old-school methods (Cook & Mechner, 1962, p. 5).

Vestibule training emerged as a novel and eclectic model circa the 1900s and remained popular for almost four decades. This form of training addressed the problems of the classroom and offered a scenario to combine the benefits of classroom and OJT (Smith, 1942 as cited in Sleight, 1993). In this model, training takes place in an adjacent location to the factory that has the same or equivalent pieces of equipment used in the job. The instructor is an experienced practitioner and participants are usually comprised of six to ten people unlike crowded classrooms (Oakes, 2014). Thus, vestibule training managed to merge the speed of the classroom with the authenticity of the OJT to some extent. However, it was costly to establish and maintain such installations and experienced workers were occupied with training instead of contributing to the production (Sleight, 1993).

The World Wars: Systematic Training

The profession of training has undergone a remarkable transformation due to the world wars in the first half of the 20th century. The western world found itself in dire need of a huge number of trained employees for transitioning to a wartime economy whereas the majority of the already trained workforce was being enlisted. Consequently, authorities started to seek for a feasible, scalable and effective way of training people for work (Torraco, 2016). Charles R. Allen proposed a four-step method of OJT throughout World War I which addresses the demand for quick and thorough training of employees. The so-called “show-tell-do-check” method paved the way for early principles of training when reinforced by the research efforts of the US Army (McCord, 1976). Even though sets of principles were formed and applied in training activities, systematic training processes were not present until the World War II era (Oakes, 2014).

World War II was an unprecedented phenomenon that forced nations to train their workers to keep up with the overwhelming pace of the wartime industry. The capacity of the vocational schools at the time was inadequate to meet the needs in terms of the workforce (Steinmetz, 1976). Thereby, the Training Within Industry initiative of the US War Manpower Commission started a program called Job Instruction Training, abbreviated as JIT (Sleight, 1993). The JIT was designed to teach supervisors at workplaces how to teach their knowledge and skills to their direct reports and hence it is considered as one of the earliest examples of systematic training efforts in the form of a train-the-trainer program (Oakes, 2014). The JIT was based on the four-step method of the early 1900s and was applied on a very large scale. Dooley (2001) reports that the JIT enabled the creation of technical training programs in more than 16.000 manufacturing facilities. The Training Within Industry initiative was terminated by the end of World War II and it made the training of 23.000 trainers and certification of almost 1.8 million supervisors possible (Torraco, 2016). Upon achieving large-scale workforce deployment, the training departments had secured their places within organizations even after the war era.

In the post-war world of the 1950s, the need for trained workers was still enormous as economies were boosted by efforts to reconstruct the devastated infrastructures and businesses. Therefore, the lessons learned in the field of training from the wartime economy have been widely adopted and improved by many organizations in time (Torraco, 2016). Organizations and researchers started to concentrate more on the systematic implementation of training with respect to successful outcomes obtained throughout the war. This decade was marked as the time when foundations of instructional systems design (ISD) were laid according to Oakes (2014).

Individualized Instruction

Considering that training departments were widely established and recognized during the war, organizations began to investigate cheaper and more effective methods for training activities (Sleight, 1993). Skinner's groundbreaking book titled "Science and Human Behavior" introduced the behaviorist theory of learning and based on top of that another innovation was born: "individualized instruction" (Oakes, 2014). Individualized instruction, in a sense, replaces the instructor with the material and thus allows the trainee to determine the pace of progression into content (Slavin, Leavey & Madden, 1984). Therefore, it was regarded as the cheaper and effective new solution for the expectations of the organizations. This approach was subsequently automated in the form of a mechanical device famously called the "teaching machine" (Skinner, 1954 as cited in Molenda, 2008). It was arguably the forerunner of computer-based training. Although the teaching machine cut the training time (Cook & Mechner, 1962, p. 13) and enabled learners to adjust their paces, it provided a mostly linear progression based on an expensive design cost which then needs to be transferred to work (Sleight, 1993). Notwithstanding, programmed instruction was widely practiced and has been highly influential in the following decades as well (Molenda, 2008).

A different aspect of the emerging ISD approach was led by the original work of Bloom’s taxonomy of learning objectives (Bloom, 1956). Individualized instruction required job analysis and needs assessment before any implementation. The taxonomy also helped emphasizing the pre-training stage as it categorizes the types of knowledge or skills to be taught (Oakes, 2014). Bloom's work is a significant contribution to training as it promotes the idea that different teaching strategies and methods should be followed for different types of learning objectives. Afterwards, the training community was introduced a new theme in the field at the end of the decade: “measurement”. As pre-training stages had gained gradually increasing importance, Kirkpatrick (1959) presented his model for training evaluation and thence drew attention to post-training stages as well. Focus on measurement preceded the realization that training practitioners and directors should comprehend the business cases in which they operate (Estep, 2008). It has become more and more important to justify the benefits of training programs as they transformed into a systematic, long-lasting and large-scale endeavor over time. The emerging field of human performance technology, HPT in short, also encouraged the efforts of concerning business results along with training objectives (Oakes, 2014). As measurement and evaluation came into prominence, a notable contribution in the literature helped training designers to define learning objectives in a well-structured way. Mager's (1962) approach provided training designers with a framework that describes an observable instance of behavior, the conditions to observe it, and the level of desirable performance on that behavior. Hence, it gained popularity in the community.

Instructional Systems Design

According to Heinich (1970), programmed instruction can be regarded as an early example of systems approach in instruction since it involves breaking the content into pieces through analysis, determining the steps to achieve objectives and confirming whether the program resulted as expected. ISD models departed from previous training methods since they highlight the significance of needs assessment before training along with the evaluation of program efficiency after the training (Torraco, 2016). From that perspective, Bloom's (1956) and Mager's (1962) works consolidated the pre-training aspect of the emerging systems approach whereas Kirkpatrick's (1959) and Glaser's (1963) contributions conceptualized the post-training features. Subsequently, several efforts were made to tie concepts like task analysis, objective writing and criterion-referenced testing together for creating a model of systematic instructional design (Reiser, 2001). The 1970s was a particularly active and productive period for ISD. Many models were suggested in that era (e.g. Dick & Carey, 1978; Gagne & Briggs, 1974; Kemp, 1971). Likewise, the 1990s witnessed another burgeoning of interest in the ISD with the addition of new models (Kemp, Morrison & Ross, 1998; Smith & Ragan, 1999) and revisions to previous ones (Dick & Carey, 1996; Gagne, Briggs & Wager, 1992).

Gustafson & Branch (2002b) points out that even though numerous ISD models have been identified, all of them have five core elements in common: Analysis, Design, Development, Implementation and Evaluation. Thence, one of the most popular acronyms in educational literature, the ADDIE, is formed (Torraco, 2016). ISD has been a fundamental framework in the training and development community by expanding its application areas in line with emerging trends. For instance, performance technology movement, rapid prototyping and online learning waves were embraced by ISD theorists and practitioners, and thus the framework extended its interpretations and tools (Reiser, 2001).

Computer-Based Training

As a matter of fact, Mager’s model was developed for the case of programmed instruction which will be automated through a new type of machinery, namely the computers (Estep, 2008). Gery (1987) states that computer-based training, or CBT in short, was initially started on mainframe computers of the 1970s in relation to their increasing capabilities and decreasing costs. Computers extended the reach of individualized instruction in two ways. Firstly, computers provided automatized branching and scoring ability which translates into a more customized and enriched experience for the trainee. Secondly, computers have later become able to present the content in multimedia form and enabled peers to connect in various ways (Sleight, 1993). Computer-based training has preserved and consolidated its place within training modalities until today.

The 1970s and 1980s

The 1970s witnessed two more major developments for the training community along with the onset of the CBT wave. First of all, Malcolm Knowles published his seminal book “The Adult Learner: A Neglected Species” in 1973 which has turned out to be a primary reference for training designers. Knowless (1973) differentiated the learning of adults from children and proposed six principles summarizing the main differences. The term “andragogy” was also coined by Knowless. Subsequently, many researchers and training experts advocated that instructional activities in the workplace must be designed by taking andragogical principles into account since participants of these activities are typically adults (Knowless, Holton & Swanson, 1973). Secondly, another classical work in the history of instructional design was published only one year after Knowles’ influential contribution. Nine events of instruction which is arguably the most famous template for lecture design to date (Richey, 2000) was presented for the first time in “Principles of Instructional Design” (Gagne & Briggs, 1974). Gagne not only provided a prescriptive guideline based on cognitive mechanisms but also promoted cognitivism as a new learning theory (Estep, 2008). By the end of the 1970s, the main pillars of the training literature were established such as modalities (OJT, classroom, CBT, etc.), instructional systems design, learning objectives, learner characteristics, instructional principles, and evaluation.

The 1980s, on the other hand, marked the beginning of a deceleration in many economies after historical demand for workforce training for several decades (Oakes, 2014). As a result, organizations took measures to survive challenging global competition and an economic recession that is the most severe one since World War II (Moy, 1985; Kose, Sugawara & Terrones). Organizations responded by looking for options to cut spendings including training budgets. Consequently, executives started to question the value of training investments and their contribution to bottom-line business objectives which encouraged the community to focus more on the concept of return-on-investment (Estep, 2008). The training community undertook a process of conceptualization and redefining its identity in line with the pressure and skepticism caused by the unstable economics of the era. Correspondingly, two different competency models for trainer qualifications were put forward in this decade. Eventually, training and development were tied together in an attempt to position the field of training as a function of the broader field of human resources (Oakes, 2014). McLagan (1989) revitalized the term “Human Resource Development” by integrating career development and organizational development with training and asserted that these components need to function in harmony to achieve organizational effectiveness.

The 1990s: Learning and E-Learning Organisations

Advancements in personal computers and internet technologies defined the era. Although CBT dates back to the 1970s, the 1990s turned out to be the golden age of CBT and its derivatives such as e-learning or online learning (Tavangarian, Leypold, Nölting, Röser & Voigt, 2004). Computers have gone beyond being simple tools of automation for programmed instruction because manufacturing operations ceded their status to knowledge work for being the primary source of added value

(Scardamalia, Bransford, Kozma & Quellmalz, 2012). At that point, computers emerged as the new machinery, or at least a fundamental one among others, for commercial products and services. Therefore, computers are now part of the skills or knowledge to be taught.

Torraco (2016) argues that the widespread use of personal computers in the 1990s was an opportunity to reconsider the established means of training since CBT in its new forms is now much more accessible, scalable, cost-efficient, and capable of stimulating multiple senses. Both e-learning and web-based learning scenarios had their inherent drawbacks though. It was a serious challenge to keep the trainee engaged and to keep the content up-to-date (Estep, 2008). Nonetheless, programmed instruction was not the only convenient case for CBT. Performance support tools have been in use since the 1940s but improved technological capabilities of the 1990s enabled it to be embedded into work as a far more accessible tool for workers (Sleight, 1993). Accordingly, the focus shifted to training activities' role and ability in performance improvement (Rummler & Brache, 1995 as cited in Torraco, 2016).

Organizations did not solely focus on performance improvement though. The concept of the "Learning Organisation" was introduced which suggests broadening the scope of development from individual level to organizational level (Senge, 1990). Senge's "The Fifth Discipline" remained one of the most influential management books to date and had various implications regarding the perception and implementation of training activities. According to Senge (1990), there are five disciplines affecting the emergence of a learning organization which are personal mastery, awareness of mental models, a shared vision, team learning, and systems thinking. The fifth one, systems thinking, is the emphasis of the book since the key proposition of the author is that all five are highly interconnected in a larger context. Hence, they need to be perceived as a whole and every intervention or decision within the organization should be based on a systemic understanding (Senge, 1990).

Each of the four disciplines is intertwined with training activities, especially personal mastery and team learning. Torraco (2016) portrays the direction of transformation in training “from classroom to computer and from there to realistic context”. Because the workers were required to understand the operations as a whole not limited to their particular role within the process as the complexity of job-related processes increased over time (Swanson & Torraco, 1995). Senge's (1990) perspective was well-aligned with the direction of the evolution of the workplace and hence it inspired many organizations. It can be concluded widespread CBT, performance improvement and organizational learning were prevalent themes in training throughout the 1990s (Oakes, 2014).

The 2000s and Today: Talent Management

Kraiger (2014) examines the historical development of training research in four phases: scientific management (1900–1930), humanistic (1930–1960), participatory (1960–1990), and strategic (1990–present). As per his characterization, strategic perception of training became evident in the 2000s. The rise of training activities to a strategic level of importance is closely related to what is called “The War For Talent” (Chambers, Foulon, Handfield-Johns, Hankin & Michaels III, 1997) which implies a major paradigm shift. Conventionally, people are expected to compete for being hired. However, changing dynamics of the economy and technology compelled organizations to compete in human capital markets in order to survive and grow (Boudreau & Ramstad, 2007, p. 20). As job descriptions got more complicated, employability has become a more prominent issue than employment (Stuart, 2019). Therefore, organizations concentrated on attracting a limited number of people who are employable for complex new workflows of the knowledge society (Reigeluth, 2009). Competition in talent acquisition has yielded a boost for training and development activities. Because they are crucial for both convincing new talent to join (Bartlett, 2001; Schmidt, 2010) and remaining competent by developing existing talent to avoid further talent gaps. Correspondingly, the number of research publications concerning training peaked during the 2000s (Bell, Tannenbaum, Ford, Noe & Kraiger, 2017).

Along with its fortified status, training activities have undergone a structural expansion as well. Myers (1999) asserted that the pace of dissemination of information has finally overwhelmed the infrastructure of instructional systems. That was more than 20 years ago. Hence, training and development was required to go beyond formally structured events. The trend of exploring informal learning in the workplace stemmed from various changes that gradually occurred since the 1980s. Interest in learner characteristics and transfer of learning were primary themes in the 1980s (Bell, Tannenbaum, Ford, Noe & Kraiger, 2017). Because training budgets were being questioned due to economic slowdown and researchers were forced to understand how trainees respond or approach to training programs and how they can apply what is learned. Efficiency was a major concern. As a result, constructs like motivation or self-efficacy spurred interest within the training community (Latham & Frayne, 1988). This trend stretched into the 2000s with ever-increasing emphasis and currently, learner-centered training design has admittedly been a priority (Oakes, 2014). When the learner is placed at the center of the workplace training design, the ubiquitous nature of learning is recalled. Consequently, informal learning in the workplace was addressed more frequently than ever in the 21st century.

Training professionals are now expected to not only design structured programs but also provide employees with opportunities and tools for self-learning and even content creation. Oakes (2014) highlights that training departments have gradually evolved from being the only provider of instruction within the company to a facilitating mechanism that promotes knowledge sharing and social learning through peer interactivity. Technological advancements accelerated this progress. Modern employees can now share their expertise through easy-to-use content creation tools and they can effortlessly interact with teammates using mobile devices. Providing that, informal learning is recognized as it accounts for a significant amount of learning happening in the workplace (ASTD and i4cp, 2013). Contemporary training and development practices now need to utilize concepts like just-in-time learning (Brandenburg & Ellinger, 2003), mobile learning (Keegan, 2005), gamification (Armstrong & Landers, 2018), and virtual reality (Kaplan et al., 2020) beyond classical training forms.

The Summary

The training profession has undergone a substantial transformation in accordance with the societal, economic, and technological developments throughout history. The 20th century altered the speed of this change unprecedently due to major incidents or phenomenons like The Great Depression, The World Wars, industrialization, advancements in psychological literature, the invention of computers, the internet, and globalization. As of today, training and development is an integral part of the talent management framework. It is expected to be learner-centered, technologically assisted, accessible, social, evidence-based, and aligned with strategical bottom-line objectives in organizations.

A summary of the evolution of the training profession is presented in Figure 1.1

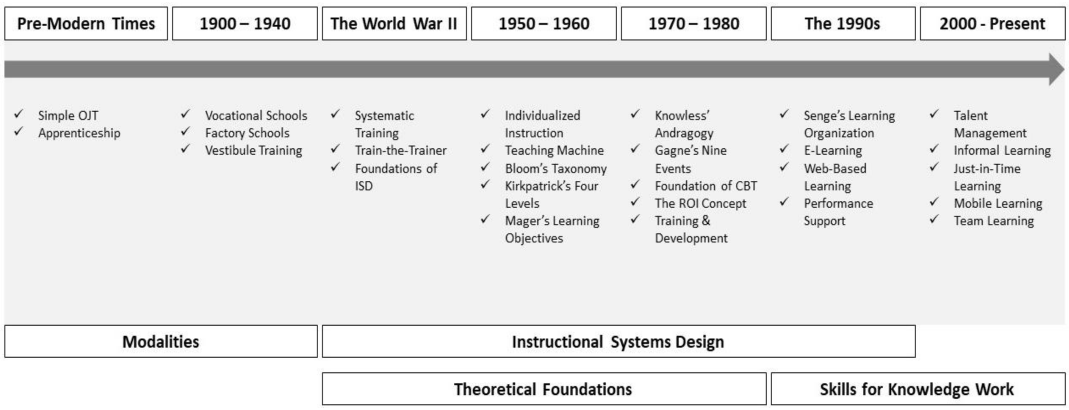

Figure 2.1. Historical development of training and development

2.1.2 Workplace Learning

The phenomenon of learning has been attempted to be interpreted chronologically by first looking at behavioral changes (Skinner, n.d.; Thorndike, 1913), then cognitive processes (Atkinson & Shiffrin, 1968), and finally interactions within a specific context (Anderson, 1996). In the case of workplace learning, context is the main difference considering that majority of research on learning focused on formal school settings (Tynjälä, 2008). The problem of workplace learning is closely related to another controversial issue which is the fact that the outcomes of formal education systems are not aligned with expectations at the workplace. Eraut (2004) puts forward that most of the knowledge or skills taught in schools, tertiary education in particular, is not necessarily addressing occupational competencies. This much-debated gap between schools and work organizations has been widened by the increasing pace of change in the nature of work and business as briefly stated in Reigeluth (2009). Hence, work organizations had to pay more attention to learning in the workplace (Billett, 1995).

The focus of research on workplace learning is expectedly centered around the context and settings in which learning takes place. Accordingly, various researchers in the field suggest that common interpretations of learning are derived from school settings and therefore they can not be directly transferred to the workplace (Tynjälä, 2008). For example, Hager (2004) argues that the research on workplace learning should follow a different path than general educational literature. According to proponents of this perspective, learning is not a neutral cognitive incident but rather it is inherently contextual (Hager, 2005). A constructivist approach to learning with a high emphasis on socio-cultural interactions is adopted herewith. There are indeed many opportunities for means of social learning such as peer-guidance, coaching, scaffolding or cognitive apprenticeship (Collins, Brown & Newman, 1989) in the modern workplace (Billett, 1995).

Resnick (1987) provides a comprehensive comparison of learning at school and learning in the workplace by stressing out four key differences which are summarized in Table 2.2.1

Table 2.1.1 Key Differences Between Formal And Workplace Learning

Learning in formal education	Learning in the workplace
Mostly individual	Mostly social
Emphasis on mental activities	Use of tools and application is expected
Manipulation of symbols	Contextualized reasoning
Generalized skills and principles taught	Situation-specific skills taught

On the other hand, Billett (2004) addresses the issue differently by stating that efforts to define workplace learning by distinguishing it from school environments are not an illuminative way of thinking. Because concentrating on “what it is” not does not provide actionable information about “what it really is”. Furthermore, contextualized interpretation of learning has its inherent limits for application. Prawat (1993) asserts that the construction of procedures takes precedence over propositions in situated learning. However, the complexity of tasks in the workplace is in an ascending trend historically and therefore the amount and depth of the conceptual base are increasing for effective work performance (Berryman, 1993). Based on that conclusion, Billett (1995) points out that planned instructional interventions which can enable the learner to comprehend higher order skills are an inevitable reality for workplace learning. Therefore, it is problematic to characterize workplace learning as “mostly informal” with respect to the need for structured training and the fact that typical workplace is a highly regulated environment with predetermined rules, hierarchies, authorizations and inspections (Billett, 2004). There is a tendency in the literature to regard it as informal though (Fenwick, 2008a; Tynjälä, 2013).

Workplace learning and formal learning are highly intertwined yet many scholars work on distinguishing one from the other. A good example to demonstrate how that relationship is complicated is so-called work-based learning. Namely, the blurring lines between universities and workplaces. Robertson (1998) highlights the importance of a model where universities are not confined to their campuses and reach out to workplaces to contribute to organizational development. Such kind of co-operation between academic institutions and organizations can be executed under several scenarios ranging from single courses or project-based certificates to customized and comprehensive programs addressing the needs in the workplace rather than the established curricula (Boud & Solomon, 2001). Another detail often overlooked about comparisons of workplaces and schools is that workplaces are not uniform which is almost the case for schools. Even though each school has internal dynamics of its own, schools have common structures and policies because they are typically governed by certain central bodies. However, workplaces are unlimitedly diverse environments in terms of policy and structure. These differences yield a large spectrum of cases in terms of how workplace learning is shaped within the organization (Tynjälä, 2008). Some organizations provide limited and controlled opportunities for learning at work due to many reasons like the organizational structure, occupational safety issues, etc. whereas certain organizations foster learning in the workplace and provide challenges for development on a consistent basis (Ashton, 2002).

Workplace learning, undeniably, offers important opportunities for the development and competitiveness of organizations. Even so, it is not without limitations. Billett (1995) identifies primary barriers in workplace learning as elaborated in Table 2.2.2

Table 2.2.2 Barriers For Workplace Learning

Limiting factor	Explanation
Undesirable knowledge	Not every knowledge attained in the workplace is appropriate
Access to activities	Lack of guided access to activities
Reluctance of experts	Experts are not always keen to spare time for teaching or coaching
Absence of expertise	Expertise might not be present or accessible
Opaque knowledge	Knowledge might not be explicit
Instructional media	Knowledge embedded in media is often disembodied from authentic activities

After presenting main discussions in workplace learning regarding theoretical underpinnings, identity and definition issues, and barriers, this section can be concluded by relating the present study to workplace learning research literature. Fenwick (2008a) suggests that efforts in workplace learning can be classified under two main categories: a) attempts to understand how learning can be utilized to solve work-related problems and b) attempts to reveal how certain groups within organizations learn in the workplace. Providing that, this research can be qualified as an example of the former category since it concerns demonstrating how a technical training course can be designed to improve business objectives and hence solve a work-related problem.

2.1.3 Training vs Education

The difference or distinction of the terms “training” and “education” is one of the common debates among training professionals (Masadeh, 2012) and herewith it deserves a brief introduction. These terms are often used interchangeably within various contexts though. The examination of the relationship between two terms is a perplexing task since the outcome depends on what context the question is based on. Therefore, it is important to start by explaining whether the nature of this relationship has any practical contributions to research or practice and what context or boundaries will be applied to the question.

First of all, the understanding of the definitions of training and education is valuable to some degree as it might have consequences for policies or applications of organizations. Garavan (1997) argues that the view of decision-makers or human resources specialists on treating these concepts distinctively or interchangeably will influence how learning and development activities are approached or managed. However, the research to date has tended to focus on the question itself instead of investigating how much the answer matters. One of the rare instances of literature where the value of the answer was addressed is an indirect one by Fischer (2000) which he approaches the question from a lifelong learning point of view. He suggests that training is about teaching job skills in a confined fashion and advocates that lifelong learning transcends such kinds of activities. Thence, it can be inferred that regarding training as different from education is likely to develop approaches to certain subjects.

Secondly, it is important to set the boundaries and conditions for the debate. For the sake of clarity and relevance, the issue will be elaborated with respect to four main ways of framing such a comparison. These are purpose, historical background, length, and instructional approach. An additional boundary is that the comparison is usually between training and formal education rather than informal education (Masadeh, 2012; Tynjälä, 2008). Correspondingly, the debate herein will be centered around the differences and similarities of formal education and training.

Firstly, many definitions of training have two components in common: a) being driven by job skills b) aiming at practical and immediate results (Becker, 1964 as cited in Garavan, 1997; Fischer, 2000; Truelove, 1992; van Wart, 1993). Thereby, the purpose of training is typically characterized as teaching skills related to job tasks in order to improve performance (Carliner, 2015; Reid & Barrington, 1994). On the other hand, education is generally depicted in a broader sense of purpose with a larger scope (Mules, 2014). According to Dewey (1916), education is the instrument that enables the transmission of an existing body of knowledge, achievements and values from previous generations to new ones. Likewise, Allman (1982) suggests that society expects educational institutions to prepare the youth for life by developing them according to the collective culture and vision. In terms of purpose, training is typically associated with a narrower scope and focus on applicable skills whereas education is often defined as a general effort directed at a variety of different goals (Buckley & Caple, 2009). Furthermore, Jarvis (1995) highlights that educational activities promote a generalizable understanding of the content but training activities are concerned with the application. It can be concluded that training and education have distinctive properties purpose-wise.

Second to purpose, the terms can be analyzed within their historical context. In the organizational sense, the deliberate separation of training and education as distinct processes has deep historical roots (Garavan, 1997). Customs of the pre-industrial era have been particularly determinative for this issue. Education in those times was the term for a lifelong quest for increased wisdom that is available for a small number of distinguished people. A modern definition of education by The Manpower Services Commission of the United Kingdom in 1981 is as follows:

"*Activities which aim at developing the knowledge, skills, moral values and understanding required in all aspects of life rather than knowledge and skill relating to only a limited field of activity*" – as provided in (Masadeh, 2012, p. 64)

It can be observed that the modern characterization of education is highly reflective of its nature back in the pre-industrial period. Similarly, training in that era was not publicly available. Guilds were conservatively limiting entry to the trades. The term training was referring to the skill development of the apprentice in the work context and it was expected to end when the apprentice is given the master status for demonstrating ability in all aspects of the trade (Garavan, 1997). In addition, World War II has been another turning point for the perception of the training concept. The consequences of the growth and complexity of industrial organizations in the post-war era favored the distinction of training from education (Dale, 1980). In the 1950s and the 1960s training departments were established across many organizations and trends within that timeframe shaped the general notion of training in modern times (Gross, 1977). Common practices of that period are training technical and clerical workers while educating their managers (Garavan, 1997). It can be inferred that archetypically assigned meanings and statuses for both terms originate from historical developments.

The third factor in the distinction of the terms is the customary length of activities classified under each concept. Van Wart (1993) asserts that training is focused on immediate results and performance improvement and hence it is designed for shorter time periods. Because enhanced performance is the ultimate goal and performance takes place after the training. Therefore, training time must be limited to observe the trainee on the job. Contrarily, educational activities aim to provide genuine understanding or reasoning which can be achievable in the long term (Buckley & Caple, 2009; Garavan, 1997).

The fourth and last aspect of the comparison can be the instructional approaches typically followed in each case. Before contrasting the terms, it should be highlighted that both education and training activities aim to facilitate learning and therefore a shared literature is utilized by practitioners of each field. Accordingly, a shared feature of both concepts is that they are inherently and customarily systematic (Jarvis, 1995; Reid & Barrington, 1994). On the other hand, general perspectives of learning processes are different (Garavan, Costine & Heraty, 1995). While training activities are inclined to concentrate on learning-by-doing in a more mechanistic fashion, educational activities are increasingly favoring less structured, organic learning experiences with an emphasis on active learning and socio-cognitive mechanisms (Anderson, 1996; Buckley & Caple, 2009; Garavan, 1997). Although none of the terms are subject to prohibitive rules for utilizing any kind of instructional approach, the conventional understanding of the terms encourages people to perceive each concept with certain characteristics based on historical connotations and prevailing preferences in each community.

The distinction between education and training concepts is still debatable and many cases can be proposed that challenge the boundaries in between. However, the present study can be confidently classified as an effort that addresses the training literature with respect to four aspects of distinction explained above. The current study intentionally adopted an orthodox approach to determine the limits of the research. Because one of the main purposes of the study is demonstrating a working example of using instructional design to improve business objectives which perfectly complies with conventional definitions of training.

2.2 Transfer of Training

Transfer of learning is one of the most discussed but challenging issues in learning sciences and all related fields such as training research. The earliest effort in transfer research dates back to the classic work of Thorndike & Woodworth (1901) where Because it is arguably the main aspiration of all formal education and training activities (Klausmeier, 1961; Perkins & Salomon, 1992). Royer (2009) highlights that it is difficult to name any other topic more central to the educative processes than the transfer of learning. Typically, the context of learning (classrooms, tests, etc) is significantly different from the ultimate context of implementation (on the job, outside school, etc) and thence the transfer is the key ingredient for an effective intervention (Perkins & Salomon, 1992). Since, the purpose of formal education activities, especially training programs, is not ensuring learners' success in the classroom. The essential purpose is enabling the learner to apply what is learned outside the original context of learning, namely, in real life events or authentic job tasks (Druckman & Bjork, 1994).

2.2.1 Nature of the Transfer

Although the transfer is a central component of instructional activities, it is not straightforward to define, distinguish or classify the concept of transfer. A plethora of definitions has been provided for the concept from both instructional and psychological perspectives. Carpenter (2012) proposes that the transfer can be broadly described as the application of previously learned knowledge to new situations. Likewise, Mestre (2002) puts forward that the transfer is the ability to apply knowledge or procedures from the learning context to a new one. In line with these, Newstrom (1986) includes the performance dimension by suggesting that transfer is about determining if learning in one case will foster learning, and thence the performance, in a similar subsequent case. Various definitions with a similar approach can be found in the literature. In a general sense, the transfer is associated with obtaining and preserving knowledge or skill to utilize on a later occasion. However, this interpretation of transfer is comparable to ordinary learning. Because learning requires a later demonstration of what is attained and different occasions are likely to have different conditions to some extent (Perkins & Salomon, 1992). From this perspective, it can be inferred that a modicum of transfer is embedded in learning.

A thorough examination of the nature of the transfer reveals that it is more complex and multifaceted than many people believe. A line should be drawn between ordinary learning and the transfer, to begin with. For that purpose, the expected degree of dissimilarity between contexts should be determined to identify a "new context" and the length of the timeframe should be specified to identify a "different occasion". That is the criterion problem introduced by Baldwin & Ford (1988). In their comprehensive review of the transfer of learning literature, Baldwin & Ford (1988) provides a framework to clarify the understanding of transfer and the factors affecting it. This framework depicts the process of transfer threefold: inputs, outputs, and conditions as shown in Figure 2.2.

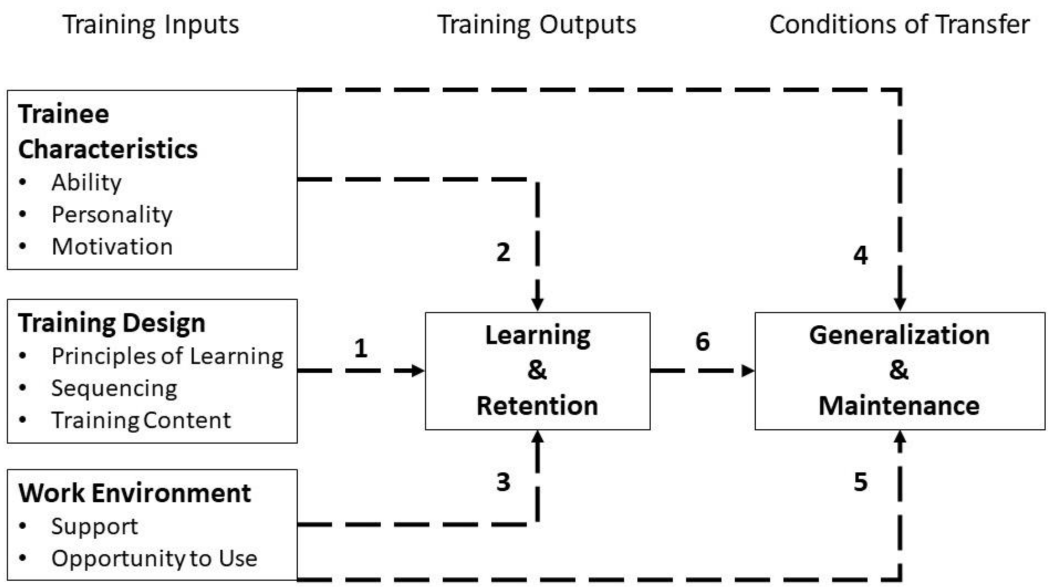

Figure 2.2. A model of the transfer process by Baldwin & Ford (1988)

A notable contribution of this model is the fact that it describes two conditions of transfer. Generalization refers to the degree to which learned knowledge or skills are demonstrated in the transfer setting whereas maintenance is about the span of time that the use of learned knowledge or skills persist (Baldwin & Ford, 1988). The model also presents and elaborates the inputs that account for the occurrence of the transfer in terms of the most influential trainee characteristics, relevant components of training design, and required settings in the workplace. The model and the current status of the literature were reevaluated through a subsequent effort by Ford & Weissbein (1997) which reports that transfer research began to focus on more complicated and diverse tasks and the work environment spurred more interest after the original study.

On the other hand, Perkins & Salomon (1992) suggests a different approach to the conditions of the transfer. They assert that the transfer is possible when five essential conditions are satisfied. These conditions can be briefly described as follows:

Thorough and Diverse Practice: A piece of knowledge or skill, in particular, can be transferable after an extensive practice plan spanning a wide range of different types of practice at hand. The frequency and diversity of the practice can increase the familiarity of a different situation.

Explicit Abstraction: The transfer also relies on learners' level of abstraction regarding the critical components of the solution in the original context. The abstraction refers to the mindful analysis of the situation in order to find out principles, associations, and boundary conditions which can be used as guidelines for another context.

Active Self-Monitoring: When learners are encouraged to actively reflect on their thought process underlying the solution, they are likely to develop an understanding and formulation for future tasks. Active self-monitoring concerns cognitive procedures of the learner which contrasts with the emphasis of explicit abstraction on the structure of the situation.

Arousing Mindfulness: This is a mental state which enables the learner to engage with the given task and the environment in an alerted way. A mindful state necessitates a continuously active involvement rather than automatic responses. Mindfulness is capable of promoting both explicit abstraction and active self-monitoring.

Using a metaphor or analogy: The use of metaphors or analogies facilitates the transfer since the learner can make sense of the new material based on previous knowledge. Analogies or metaphors can serve as scaffolds in the new situation.

Explanations of Baldwin & Ford (1988) and Perkins & Salomon (1992), when combined, provide a substantial perspective on the conditions which leads to the transfer of learning. Table 2.3 presents the suggestions of two studies. Conditions from Perkins & Salomon (1992) are associated with those proposed in Baldwin & Ford (1988) in terms of having similar consequences.

Table 2.3 Conditions Of Transfer From Two Different Perspectives

Perkins & Salomon (1992)	Baldwin & Ford (1988)
Explicit abstraction Active self-monitoring Arousing mindfulness	Generalization
Thorough and diverse practice Using a metaphor or analogy	Maintenance

A third and more recent attempt to clarify the conditions of transfer based on a substantial review of published research was presented by Day & Goldstone (2012). Although they shared common ground with two studies summarized in Table 2.3, they drew attention to certain nuances as well. For instance, the concept of "surface similarity" was stressed out. According to Day & Goldstone (2012), surface-level alignments between learning and transfer contexts are extremely important in the facilitation of transfer yet they are generally overlooked for the sake of deep structural similarities. Surface similarities help the learner to recognize that there is an opportunity for transfer in the first place. Therefore, such kind of realization might be considered as a precondition for the transfer of learning. Another important issue addressed by Day & Goldstone (2012) is the sensitive balance between abstraction and concreteness. They highlighted that each property has contributions and limitations for the transfer. Concrete examples help the learner to build mental representations that are essential for the comprehension of the subject. However, such examples may also lead to bounding to a particular context which hinders the ability to recognize new but similar contexts. In the same way, abstraction is useful in exploring the structure of the subject but lack of specific examples may suspend precise representation of the information rendering it untransferrable. One last contribution from Day & Goldstone (2012) was the emphasis on the consequences of so-called cognitive load (Baddeley, 2000). They remind that the capacity of the working memory is a critical constraint affecting both learning and transfer since it imposes the amount of information to be processed for constructing transferable associations. Consequently, they put forward that premises of the cognitive load theory (Sweller, van Merrienboer & Paas, 1998) should be considered to achieve the transfer of learning.

One more aspect should be addressed before concluding the discussion of the research on conditions of transfer. The majority of the research tended to focus on the conditions for facilitating the transfer in terms of environmental properties or instructional strategies. However, the occurrence of the transfer can not be reduced to a function of comparison between original and new contexts. The transfer is a cognitive process carried out by the learner which requires awareness and desire to do so (Goldstone & Day, 2012). Accordingly, the motivation of the learner for seeking out and constructing associations for new situations is an integral part of the conditions enabling the transfer. Nonetheless, the significance of the role of motivation in the transfer of learning has been underemphasized, particularly in the field of cognitive sciences (Belenky & Nokes-Malach, 2012). Any depiction of fundamental conditions for transfer will not be complete without acknowledging the learner as the actor of the process and thus taking the feature of the learner into account along with teaching strategies or contextual factors (Goldstone & Day, 2012).

Upon setting the scene for a comprehensive understanding of the transfer, more specific definitions of the concept can be discussed. That is, in contrast with naive and simplistic framing of "using prior knowledge in a new context" propositions such as Mestre (2002) or Carpenter (2012).

Following are three comparable definitions of the transfer of learning that refers to the underpinnings of the concept within a workplace context:

> "*Training transfer is the extent to which the learning that results from a training experience transfers to the job and leads to meaningful changes in work performance*" (Baldwin, Ford & Blume, 2009).

> "*Transfer of training is defined as the extent of retention and application of the knowledge, skills and attitudes from the training environment to the workplace environment. In other words, transfer of training is the degree to which trainees effectively apply the learning from a training context to the job*" (Subedi, 2004).

> "*Transfer of training is defined as the degree to which trainees effectively apply the knowledge, skills, and attitudes gained in a training context to the job*" (Wexley & Latham, 1991)

Definitions are getting diversified across different types of taxonomies of the transfer as the level of detail in the descriptions increase. Although there are numerous ways of classifying the concept of transfer, this section will concentrate on the most recognized and most relevant approaches with respect to the purpose of the present study.

First of all, the occurrence of the transfer of learning can be classified based on its effect on the learning outcomes. The transfer can either enhance or undermine the outcome in the new context which constitutes the basis for the positive transfer vs negative transfer dichotomy (Perkins & Salomon, 1992). Positive transfer can be identified through certain indicators such as the presumption of prior learning of knowledge and skills in a training context, demonstration of learned knowledge or skills on the job, and preservation of what is learned over a considerable time period (Newstrom, 1986). On the other hand, the negative transfer is indicated by an inhibitory effect on learning in the job context due to prior learning in the original context (Ellis, 1965 as cited in Burke, 1997). Perkins & Salomon (1992) asserts that negative transfer is a lesser concern for instructional studies since it is only problematic in the early stages of learning within a new domain and gradually ceases to affect the process. Accordingly, the majority of the research focuses on positive transfer as well (Burke, 1997; Day & Goldstone, 2012; Lionetti, 2012; Mestre, 2002; Michalak, 1981; Subedi, 2004; Wexley & Baldwin, 1986).

A second way of classification for transfer of learning is based on the level of complexity and it was introduced by Gagne (1965). In order to understand this classification, another seminal work of Gagne must be revisited. Gagne (1968) proposed a "learning hierarchy" which is a collection of cognitive capabilities in a relational order so that each level of capability is an essential precondition for the next level. Gagne's learning hierarchy is comprised of four discrete types of learning: discrimination learning, concept learning, rule learning, and higher order rule learning (Gredler, 2009, p. 157). The lateral transfer vs vertical transfer distinction is built upon the direction of transfer in terms of these learning levels. From this vantage point, lateral transfer refers to the occasion when learned knowledge or skill is applicable to a different case with roughly the same level of complexity with respect to the learning hierarchy (DuBois, Alverson & Staley, 1979 as cited in Teich, 1987). In other words, lateral transfer is a generalization confined within a particular level of complexity (Gagne, 1985). The vertical transfer, however, is a vertical movement in terms of complexity as the term implies. It occurs when learned knowledge or skill directly contributes to the acquisition of a higher level skill or knowledge (Royer, 2009). Figure 2.3 depicts the relationship between Gagne's (1968) learning hierarchy and types of lateral and vertical transfer.

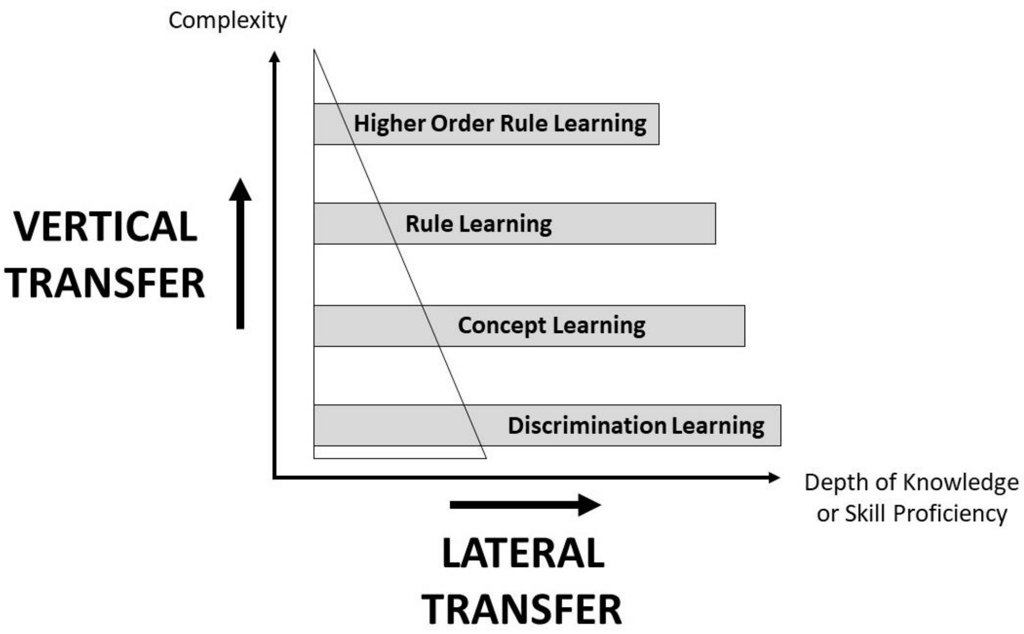

Figure 2.3. Relationship between learning hierarchy and lateral/vertical transfer

It should be noted that vertical transfer has traditionally received the most attention from psychologists and educators alike.

The third kind of classification for transfer of learning depends on the level and type of mental effort utilized in the course of the transfer. There are two different approaches following such type of reasoning to distinguish the occurrences of transfer. Perkins & Salomon (1992) claims that the transfer of learning can be either reflexive or mindful. The reflexive transfer involves semi-automatic precipitation of previously learned routines by stimulus patterns similar to those found in the original learning context. Mindful transfer, in contrast, involves explicit abstraction and reasoning based on learning context followed by a conscious quest for connections or patterns in the subsequent context. In that sense, mindful transfer requires reasonable time and allocation of deliberate mental effort where reflexive transfer is more about well-automized responses to the new situation (Perkins & Salomon, 1992). In addition, Royer (2009) introduces a distinction of transfer incorporating different terms with similar concerns. That is, the transfer can be literal or figural. Literal transfer refers to occasions where an intact skill or knowledge is directly applicable to a new context. But figural transfer necessitates the use of general knowledge to contemplate and explore the new situation (Royer, 2009). Providing that, it can be inferred that reflexive transfer is well aligned with literal transfer whereas mindful transfer is comparable to figural transfer.

The fourth and arguably the most addressed type of classification for transfer of learning is about the level of similarity between the original context and the transfer context. Mayer (1975), points out that near transfer is the transfer of learning between similar cases while the far transfer is the type of transfer that happens by means of reasoning and interpretation within the novel context. Royer (2009) provides a very convenient conceptualization for the purposes of the present study which states near transfer can be considered as the transfer between two school-bound (or training-related) situations whereas far transfer can be understood as the transfer from a school-bound (or training-related) situation to a real World (job-related) situation.

In the conclusion, the existing body of knowledge proves that the concept of transfer of learning is a multidimensional and substantial component for both formal education and workplace training. Upon reviewing the definitions, conditions and different classifications of the phenomenon, a particular taxonomy will be elaborated in the next subsection in order to shed light on the theoretical understanding adopted by the present study.

2.2.2 Haskell’s Taxonomy of Transfer of Learning

There was an obvious need for a general framework of the concept after a century of widespread focus on research concerning the transfer of learning. “Transfer of Learning: Cognition, Instruction, and Reasoning”, a pioneering work by Haskell (2001), has influenced subsequent research on the topic of transfer. The book elaborates on the definition and underlying mechanisms of the transfer and then provides two taxonomies addressing the levels and types of the transfer.

Haskell (2001) suggests that the term "transfer of learning" refers to how previous learning affects current and future learning, as well as how previous or current learning is applied to similar or novel circumstances. Providing that, Haskell identifies two principal issues that hinder our understanding of the transfer; the need to distinguish between levels of transfer and types of transfer, as well as the need to establish a taxonomy for each (Calais, 2006). Then, he devises the taxonomies by cautioning that categories of the models are not mutually exclusive.

The first taxonomy of Haskell concerns the degree of similarity across six progressive levels (Foley & Kaiser, 2013). Thus, Haskell (2001) provides increased sensitivity in terms of distinguishing similarities between contexts considering that the near transfer vs far transfer duality has been the most adopted approach previously (Calais, 2006). Furthermore, Haskell (2001) produces a measure of distinction between ordinary learning and the transfer by associating his levels with either one or the other. Table 2.4 shows the levels of transfer according to Haskell's (2001) taxonomy.

Table 2.4 Haskell's (2001) Taxonomy For Levels Of Transfer Of Learning

Level of transfer	Explanation
Nonspecific transfer *(Level 1)*	It is the trivial explanation of transfer as it implies any kind of learning is transfer since learning is inherently based upon previous learning.
Application transfer *(Level 2)*	It implies the application of learned knowledge or skills to a particular situation.
Context transfer *(Level 3)*	It is the application of learned knowledge or skills to a slightly different situation by means of cues from the past.
Near transfer *(Level 4)*	It happens when learned knowledge or skills are transferred to a similar but not identical situation.
Far transfer *(Level 5)*	It is the transfer of learning to a completely different situation than the initial one by means of analogical thinking.
Displacement or creative transfer *(Level 6)*	This kind of transfer is capable of the creation of a new concept through realizing a similarity or connection between the new and old.

According to (Calais, 2006), only level 4, level 5 and level 6 qualify as significant forms of transfer while lower levels are either mere instances of learning or application of what is learned. In this sense, Foley & Kaiser (2013) present examples to help clarifying near and far transfer. For instance, the shift from driving a car to driving a truck is a classical example of near transfer. Because the case of truck driving is structurally similar to the case of automobiles. However, trucks have their own unique conditions, features, and rules that need adaptation. Conversely, the novel context is dissimilar to the original one in the case of far transfer. To illustrate that, an example of a high school student can be useful where the student learns certain maths formulas and thence utilizes them in a problem solving process to design a basic electrical circuit for the physics class. Although previously learned formulas are fundamentally required in the course of problem solving, the design of the circuit represents an entirely different context compared to the maths class where the formulas are reviewed as associations between variables. Haskell (2001) asserts that a comprehensive knowledge base is a precondition for the occurrence of transfer, especially for higher levels, as it serves as the foundation for critical thinking and reasoning which enables the learner to ask questions to identify the gaps in understanding of the subject. The relation of the mathematical knowledge base to the design of an electrical circuit is a fair example of this argument.

The degree of similarity is not the only aspect of transfer reviewed by Haskell (2001). He also proposes a two-dimensional explanation of kinds of transfer. The first dimension concerns the type of knowledge that is transferred while the second dimension focuses on the type of transfer itself (Calais, 2006). Table 2.5 shows Haskell's (2001) categorization of transfer concerning the type of knowledge involved.

Table 2.5 Kinds Of Knowledge That Can Be Transferred

Kind of knowledge transferred	Explanation
Declarative knowledge	It is the descriptive knowledge of anything.
Procedural knowledge	It is the knowledge of how to conduct a procedure.
Strategic knowledge	It is the knowledge of our own mental processes.
Conditional knowledge	It is the awareness of when a particular knowledge is applicable.
Theoretical knowledge	It is the understanding of explanatory principles and relationships between phenomena.

Haskell (2001) concludes that declarative knowledge is of paramount concern in terms of transfer as it not only lays the foundation for the other four but also facilitates the elaboration of new information.

The last classification suggested by Haskell (2001) describes fourteen specific types of transfer which is not directly related to the primary concerns of this study. Also, most of the items in that taxonomy have already been discussed in previous sections. Therefore, they will only be presented in the form of a list in Table 2.6 without further elaboration.

Table 2.6 Specific Types Of Transfer

Specific types of transfer		
Content-to-content	Conditional	Lateral
Procedural-to-procedural	Theoretical	Reverse
Declarative-to-procedural	General or Nonspecific	Proportional
Procedural-to-declarative	Literal	Relational
Strategic	Vertical	

In a nutshell, Haskell's (2001) taxonomy is a truly important contribution to the literature as it combines almost all different approaches in which the problem can be addressed within the multi-dimensional and complex nature of the concept of transfer of learning.

2.2.3 Far Transfer of Learning

Although early efforts in the literature of learning transfer centered around analyzing educational questions like how learning in a context affect learning in another one (Thorndike, 1913; Thorndike & Woodworth, 1901), researchers gradually incorporated the investigations of transfer with workplace training studies to improve performance (Goldstein, 1980). The transfer of learned knowledge or skills from instructional programs to authentic situations has turned out to be even more valuable and prioritized in this new context of training (Burke, 1997). At that point, a specific type of transfer emerged as a pivotal ingredient for effective training: the far transfer.

Seel (2011) refers to the ability to make previously acquired knowledge applicable to more complex contexts as the “far transfer”. Bereiter (1995) further complicates the concept of far transfer by arguing that the learner is firstly required to recognize that there is an opportunity for transfer in the novel context and thence the learner is expected to approach the new situation in an analytic and structured way with respect to previous learning and acquisitions. Day & Goldstone (2012) notes that it is more difficult to achieve far transfer compared to near transfer. The main difference between the two types of transfer is the degree of dissimilarity between contexts. The difficulty of the far transfer hinges on the fact that it is harder to recognize a transferable context as the level of dissimilarity increases. Upon awareness of transferability, another inherent difficulty of far transfer takes effect. While near transfer, especially in the workplace, often involves procedural tasks, far transfer conditions force the learner to use previously acquired knowledge or skills as a guideline in the novel context (Misko, 1995). Lastly, Subedi (2004) claims that there is a dilemma regarding the relative ease of near transfer compared to far transfer. Because it is understood that acquisition of near transfer on a particular skill is likely to be inhibitive on the far transfer of the same skill and near transfer is practically achievable. According to Subedi (2004), this situation might be accounting for the problems in the domain of transfer of training since most training activities involve procedural, near transfer related tasks.

The far transfer of learning is not only an essential condition for effective training. It has implications beyond that (Barnett & Ceci, 2002). Examination of far transfer is also a good measure of the validity and feasibility of theoretical models addressing learning and performance issues (Singley & Anderson, 1989). In addition, the far transfer can also be used as an indicator of the domain specificity of expertise which might be an essential input for certain instructional or managerial decisions (Ericsson & Smith, 1991).

The far transfer research is of paramount importance for the training community due to the investment-oriented approach adopted by the majority of the executives (Druckman & Bjork, 1994). However, a myriad of studies concerning the far transfer seems to agree on two issues. Firstly, facilitation of far transfer is a difficult and perplexing task (Brown, Collins & Duguid, 1989; Perkins & Grotzer, 1997). However, it is achievable (Perkins & Salomon, 1989) through accurate interventions such as considering certain trainee characteristics beforehand (Baldwin & Ford, 1988) as well as incorporating mindful abstraction, extensive and diverse practice with instructional design (Salomon & Perkins, 1989). Secondly, the training community has protracted issues in dealing with the question of far transfer (Barnett & Ceci, 2002).

From this point on, the terms “transfer” and “far transfer” will be used interchangeably in accordance with the addressed context and main concern of this study.

2.2.4 The Problem of Transfer

There is an increasing awareness of the so-called “transfer problem” in organizational training as concerns are raised that what is learned in training does not translate into the workplace (Barnett & Ceci, 2002; Michalak, 1981; Newstrom, 1986). The issue has grown much greater in line with today’s evolving work environment with regard to the trend toward the perception of training as a key mechanism for efficiently utilizing human capital (Ford & Weissbein, 1997). Data from several sources consistently shown that training programs often fail to enable behavioral change or to yield improvement in work performance. Broad (2005, pp. 82-84) compiles a list of studies reporting an absence or insufficient amount of transfer after training activities. A notable finding from that list states that only 15% of training content could be applied to work after a year (Newstrom, 1986). Furthermore, only a mere 10% of the training investments are estimated to be transferred to the job, according to Georgenson (1982). Another estimation reports that the rate of training transfer varies between 10% to 30% (Stolovitch, 2000 as cited in Broad, 2005).

Detterman (1993) has been one of the prominent critics of the transfer studies upon a comprehensive review of related literature. He concludes that far transfer is a very rare incident and only a few studies can provide reasonable empirical evidence to support their claim of transfer occurrences. He also notes that the rarity of the detection of far transfer cannot be explained by a lack of effort on the subject, conversely, he states that hundreds of studies addressing the issue were published. However, Royer (2009) argues that the topic has been neglected in the literature despite its recognized importance. The resolution of the conflict between Detterman (1993) and Royer (2009) can be found in how the latter justifies his claim of insufficient efforts on the subject. According to Royer (2009), the primary factor accounting for the lack of interest in the transfer is the experimental research methodology within which most of the fundamental research on transfer was carried out. He elaborates that experimental studies have not been popular within the education and training research communities due to their demanding nature. Barnett & Ceci (2002) takes a similar view on this matter as they suggest that even an extensive review of the literature does not provide an accurate grasp of the state of the problem. Because there is no common ground or framework underlying the research on transfer which results in inconsistent and incomparable empirical evidence. Both Royer's (2009) and Barnett & Ceci's (2002) perspectives explain the question of the scarcity of far transfer through methodological shortcomings. This approach essentially complies with Detterman's (1993) objections since he stresses out that studies reporting positive findings in terms of far transfer have something in common. In those studies, learners were provided with several types of cues, prompts, or strategies to recognize the opportunity for the transfer whereas other studies that fail to report occurrences of transfer attempted to observe the transfer effect as a natural behavior. It can be inferred that Detterman (1993) also associates the problem in transfer research with research design methodology rather than explaining it as an inherent feature of the concept itself. Thereby, it can be concluded that the so-called “problem of transfer” is a matter of research and practice preferences.

Since the problem of transfer is a solvable one, it makes sense to ask “how?”. First of all, a common misperception must be replaced in practitioners’ and researchers’ minds. The transfer, or far transfer, cannot be taken for granted (Perkins & Salomon, 1992). Facilitation of the transfer must be addressed throughout the instructional design and implementation processes. For instance, the knowledge acquired through training is often compartmentalized in the learner’s perception and thus the learner finds it difficult to make abstraction beyond the original learning context (Driscoll & Harcourt, 2012). In order to observe transfer, this issue must be addressed in the instructional design stages.

Secondly, the solution to the problem will be elaborated based on three types of input for facilitation of the transfer as Baldwin & Ford (1988) suggested (See Figure 2.2). A more recent meta-analytic study partly confirms Baldwin & Ford's (1988) model in terms of trainee characteristics that affect the transfer. Accordingly, trainee motivation and cognitive ability were found to be predictors of the transfer (Blume, Ford, Baldwin & Huang, 2010). This can be interpreted so that training activities must incorporate strategies to foster learner motivation (Wexley & Baldwin, 1986) as well as they need to be adjusted for the learner’s cognitive ability level. Training design is another influential factor in the transfer. Baldwin & Ford (1988) report that a significant amount of empirical evidence shows that principles shown in Table 2.7 have robust effects on transfer.

Table 2.7 Effective Learning Principles For Facilitation Of Transfer

Principle	Explanation
Identical elements	Transfer is maximized when learning and transfer contexts have identical elements as much as possible
General principles	Transfer occurs when not only directly applicable content but also general rules and underlying mechanisms are taught in the learning context
Stimulus variability	Transfer is more likely when the stimulus in the learning context is not uniform but various
Conditions of practice	Transferable practice requires distributed occasions in time, presentation of the content as a whole, complementary feedback, and overlearning after the successful performance

In addition, the conditions of transfer (See Table 2.3) suggested by Perkins & Salomon (1992) are also shown to be effective in achieving the transfer. Therefore, those five conditions (thorough and diverse practice, explicit abstraction, active self-monitoring, arousing mindfulness, using metaphors or analogies) must also be addressed in the training design to foster the far transfer. In terms of training design, the nature of learning outcomes is also found to be a moderator for other predictors like trainee characteristics or work environment. Learning outcomes within an open domain (e.g. leadership development) are found to be positively moderating the effect of predictors on transfer compared to learning outcomes within a closed or well-structured domain (e.g. computer skills) (Blume, Ford, Baldwin & Huang, 2010).

The last training input category in Baldwin & Ford's (1988) model is the work environment which refers to the support of peers and managers, possibilities to use what is learned, and consequences of transferred behavior (Blume, Ford, Baldwin & Huang, 2010). Peer and manager support is reportedly the most highly correlated work environment characteristics. Accordingly, it must be noted that facilitation of transfer, to some extent, relies on post-training interventions as well (Wexley & Baldwin, 1986).

2.3 Technical Training

Defining the borders and characteristics of the technical training is a multifaceted challenge which is also the case for the broader concept of training. The research to date, however, has not focused on neither forming a well-established categorization of training nor developing a rationale to categorize it. In a rare attempt, Swanson & Holton (2001) argue that three main categories of training are technical training, management training and motivational training. According to this postulation, technical training involves learning of process or tool-related content, management training involves learning of maintaining and leading the system by means of interpersonal dynamics, and motivational training involves learning of methods to understand and direct beliefs or values of people (Swanson & Holton, 2001; Williams, 1996). It must be noted that Swanson & Holton (2001) describe their categories as “generic” without claiming any fundamental justification.

An alternative approach can be followed to devise training categories with respect to a well-established foundation such as Bloom's (1956) taxonomy of educational objectives. Training activities can be associated with cognitive, affective or psychomotor domains (Bloom, 1956) concerning the characteristics of the learning objectives they aspire to achieve. Apparently, such an approach would have an inherent drawback. Because training activities do not have to be uniform in terms of the objectives they concern. Conversely, training objectives are determined by organizational needs and it is more likely to address more than one type of objective domain in a training program compared to restricting the program to a single one. Nonetheless, this approach can still be useful to some extent. Categorization might be decided upon the most prioritized or the most defining learning objectives of the program. In this case, psychomotor domain-oriented training would be likely to emerge as a prevailing category considering that the majority of the training activities focus on improving performance by teaching skills related to job tasks (Carliner, 2015; Jarvis, 1995; Reid & Barrington, 1994).

Training is highly associated with teaching skills, especially physical skills. This is well-reflected on numerous different definitions or characterizations of the term such that skill acquisition and being application-oriented are consistently mentioned as two main pillars of the concept (Buckley & Caple, 2009; Carliner, 2015; Fischer, 2000; Garavan, 1997; Jarvis, 1995; Swanson & Holton, 2001; Truelove, 1992; van Wart, 1993; Wills, 1994). This effect is even amplified for the case of technical training. Accordingly, the psychomotor domain is crucial in comprehending the notion of technical training yet it has been a relatively neglected area of the study compared to the cognitive domain (Romiszowski, 1999). It would be helpful to differentiate the concepts of “knowledge” and “skill” since so-called “skill development” or “skill acquisition” is the ultimate goal of technical training (Combs & Davis, 2010). Romiszowski (2009) asserts that knowledge can be described as a certain set of information that is known to the learner whereas the skill can be understood as the capacity to perform a particular task with a specific level of effectiveness. He further notes that knowledge is a two-state entity which is either possessed or not by the learner, in contrast, skill is an entity that develops over time through repetition. The distinctive nature of the two concepts is of utmost importance in order to design effective technical training. Because skills, particularly motor skills, need to be addressed differently than knowledge in the instructional design (Romiszowski, 1999). Another noteworthy distinction should also be made in the course of training design regarding the type of skill to be taught. As Romiszowski (2009) states, skills can be classified based on their sophistication such as reproductive skills and productive skills. A reproductive skill is highly repetitive and automatic in nature which involves the reproduction of a specific and straightforward procedure. On the other hand, a productive skill requires some planning for the procedure by utilizing principles, reasoning or creativity, and hence it is more sophisticated.

The concepts of skills and knowledge are elaborated beforehand. Since they are central to definitions of technical training. Although the concept of training does not have an intricate taxonomy for its subtypes, technical training has its unique place as a distinct category. Because the history of training is mostly the history of technical training (Swanson & Holton, 2001). Technical training has been the primary type of training activity historically (Swanson & Torraco, 1995). It plays a key role in defining moments of the historical development of training such as the emergence of OJT and apprenticeship, vestibule training or factory schools, wartime systematic skills training, and government-funded theoretical developments (Williams, 1996). Providing that, notable definitions and characterizations of technical training can be discussed.

2.3.1 Definition of Technical Training

In previous sections of the current study, the following training definition was derived upon reviewing a myriad of training definitions as an inclusive combination of them, considering the purposes of this study:

"*The term training typically refers to structured instructional events focusing on the necessary set of skills or knowledge for specific tasks executed in the workplace.*"

The question is how can technical training be differentiated from this general description of training? It turns out that perception and understanding of technical training vary widely among the training community. Combs & Davis (2010, pp. 9-11) report that a survey of 50 training professionals or managers working in Fortune 1000-listed organizations showed that interpretation of the technical training concept is highly diversified across sectors or the type of role within the organization. The perception of technical training was found to be depending on the background of the subject, experience level in the field, and organizational priorities (Combs & Davis, 2010). Although there is a lack of consensus in the training community, certain common themes can be noted.

Knowles & Hartl (1995) points out that it is important to identify three essential features that constitute the technical environment in order to recognize technical training. First of all, technical training often requires precision. It may be in the form of learning an exact skill, conducting a certain procedure, or performing accurately. Secondly, technical trainers are expected to be a master of the technical skill themselves in order to transfer their experience and expertise to the learners. The third feautre of technical training environments is being typically diverse spanning a wide range and variety of skills. For instance, even basic reading or maths skills might be regarded as technical skills depending on the job definition of the learner.

In light of that, a number of noteworthy definitions of technical training are as follows:

> "*Technical training is geared toward technicians and craft and skill workers who require specific expertise to perform one or more components of their jobs.*" (Carnevale, Gainer & Villet, 1990, p. 155)

> "*Technical training enables individuals to apply theories and principles of the natural and physical sciences to technical problems.*" (Williams, 1996, p. 29)

> "*Technical skills training and development focus on content that is system- or tool-specific and can be either information or hardware-oriented. It is generally thought of as people-thing or people-procedure, or people–process focused.*" (Swanson & Holton, 2001, p. 209)

> "*Technical training may be understood to mean instruction intended to help people perform the unique aspects of a special kind of work and apply the special tools, equipment, and processes of that work, usually in an organizational setting.*" (Rothwell & Benkowski, 2002)

> “*The process to obtain or transfer knowledge, skills, and abilities needed to carry out a specific activity or task, related to a specific scientific, mechanical, or specialized discipline, function, or profession.*”
>
> (Combs & Davis, 2010, pp. 11-12)

Lastly, but not least, Clark (2011) introduces a comprehensive definition and explains each of the five constituent elements in detail. According to her, technical training can be described as:

> “a structured learning environment engineered to workplace performance in ways that are aligned with bottom-line business goals.” (Clark, 2011, p. 10)

The term “structured” emphasizes that only a structured process can enable training to encompass both before, during and after stages in a consistent fashion. The term “environment” is intentionally included to highlight that technical training transcends confined events and involves a diverse range of knowledge resources. The term “engineered” implies that effective learning cannot be achieved through random processes, conversely, it requires evidence-based instructional interventions in line with organizational needs. The workplace performance element underlines that technical training is centered around job-specific tasks and cases. Finally, business goals are expressed for being the ultimate concern of all technical training (Clark, 2011).

Clark's (2011) approach to developing technical training is the primary theoretical foundation for the current study. Consequently, her rigorous definition for technical training is adopted and will be used as the reference definition throughout the present study.

2.3.2 Technical Training Design

There is a curious case regarding the technical training. Executives and decision-makers are reportedly clear supporters of technical training because it is perceived as more concrete and measurable than other types of training (Combs & Davis, 2010, p. 42). This is also reflected on the fact that technical training is generally the latest option when training budgets are subject to cuts, soft skill training being the first as their impact is arguably more arduous to show (Felstead, Green & Jewson, 2011, p. 29). Moreover, technical training is estimated to account for a major portion of whole training activities (Azad & Narashiman, 2007; Combs & Davis, 2010). In contradiction to these, an exclusive focus on technical training is rare within the training literature whereas a vast amount of research and resources are available that addresses; training as general, managerial training, leadership training, online training, or onboarding training (Combs & Davis, 2010; S. W. Williams, 2001). Literature focusing on instructional design is no exception for that. Although there is a rich knowledge base dedicated to training design, only a handful of resources are present which particularly concentrate on technical training design. Table 2.8 provides a compact list of notable resources on the subject.

Table 2.8 Notable Resources On Technical Training Design

Name of the resource	Author(s)	Publication year
Developing technical training	R. C. Clark	2011
Demystifying technical training: Partnership, strategy, and execution	W. L. Combs, B. M. Davis	2010
Instructional design for technical training	W. L. Combs, S. Peacocke	2006
Building effective technical training: How to develop hard skills within organizations	W. Rothwell, J. Benkowski	2002
Training complex cognitive skills: A four-component instructional model for technical training	J. van Merrienboer	1997
The ASTD technical and skills training handbook	L. Kelly	1995

Even though the technical training design is a neglected subtopic within the research of training design, the well-established knowledge base of instructional design literature provides considerable insights into the subject. Because the instructional design, as a discipline, is the process of solving learning problems through systematic analysis of learning conditions (Seels & Glasgow, 1998). At that point, a meaningful direction would be taking the nature of technical training into account before navigating through the knowledge base. In this case, two major considerations can be addressed.

Firstly, one distinguishing feature of technical training is that it heavily relies on subject matter experts in the roles of both the training designer and the trainer (Combs & Davis, 2010, p. 230). Williams (2001) points out that unlike the involvement of generalist trainers working in human resource departments, technical training activities are generally carried out by practicing technicians selected from the organization’s technical ranks. Due to the complex and diverse technical skill requirements of modern industry, the trend of utilizing technical experts in technical training has been growing (Clark, 1994). Since the nature of technical training requires trainers, who are most of the time a stakeholder of the design process as well, with profound skills and knowledge in the subject matter (Knowles & Hartl, 1995).

Secondly, there is an exclusive need for clarity and practicality in the course of instructional design for technical training. Because the domain itself is characterized as application-focused, concrete and goal-oriented. In addition, the involvement of people without any background in learning sciences is a necessary and common phenomenon for technical training design. Consequently, a prescriptive approach is expected to lend itself well to technical training design. According to Reigeluth (1983), descriptive models take the characteristics of the learning environment as input and postulate how those characteristics influence the actual learning process and learning outcomes in this environment. On the other hand, prescriptive models are goal-oriented and use the expected learning outcomes as input for a yet-to-be-built learning environment. Thence, these models recommend the instructional methods that will produce desired outcomes under the specified conditions (Reigeluth, 1983). Consequently, a prescriptive model of instructional design can be the priority while navigating through the instructional design literature.

From this vantage point, two relevant models of instructional design for technical training will be discussed in the following subsections.

2.3.3 van Merrienboer’s Four Component Instructional Design Model

One of the few attempts to suggest an instructional design model or guideline for the field of technical training is van Merrienboer's (1997) “Four-Component

Instructional Design Model", or "4C/ID Model" in short. According to van Merrienboer (1997), the 4C/ID model can be characterized as an instructional design model rather than an ISD model since it is directed to course or module level development, not curriculum level. Also, the 4C/ID model is more compatible with industrial and vocational contexts compared to formal education. Lastly, the 4C/ID model is eclectic in terms of balancing a strictly analytical approach and an empirical approach.

A defining feature of the 4C/ID model is that it addresses the training of complex cognitive skills in particular. Providing that, the model is comprised of four layers as summarized in Table 2.9 (van Merrienboer, 1997).

Table 2.9 Main Layers Of The 4C/ID Model

Layers	Explanation
Principled skill decomposition *(Layer 1)*	Dissociation of complex cognitive skills into its building in a hierarchy
Analysis of constituent skills *(Layer 2)*	Analysis of subskills and their interrelations regarding the performance
Selection of instructional methods *(Layer 3)*	Determination of corresponding methods and information displays for the practice
Development of a learning environment *(Layer 4)*	Building the training strategy including methods and displays in a blueprint form

Upon examining the layers, it should be noted that layer 1 and layer 2 correspond to the analysis of given complex cognitive skills whereas level 3 and level 4 involve the specification of the training strategy and features of the learning environment (van Merrienboer, 1997). Moreover, the four components, after which the model itself is named, are used to further elaborate on layer 2 and layer 3. These components are C - compilation, R - restricted encoding, E – elaboration, and I – induction (van Merrienboer & Kirschner, 2012). Figure 2.4 depicts the defining actions of each component across layers.

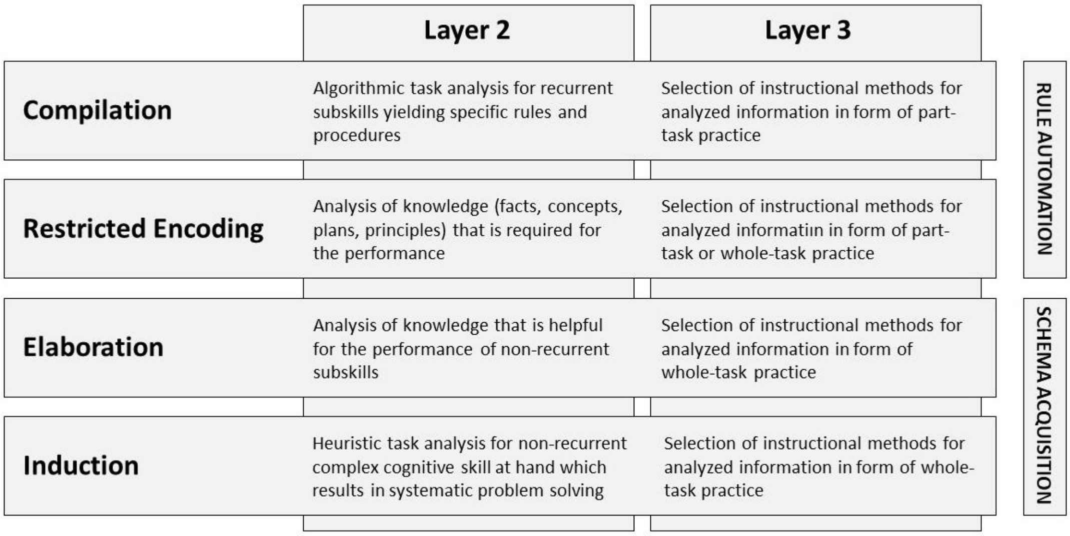

Figure 2.4. Components across layers according to the 4C/ID model

van Merrienboer (1997) labels compilation and restricted encoding components as part of the rule automation process while elaboration and induction components are associated with schema acquisition as shown in Figure 2.4. The learning process is built upon rule automation and schema acquisition from the perspective of the 4C/ID model.

The main premise of the 4C/ID model is that a well-planned learning environment addressing complex cognitive skills can be defined in terms of four interconnected “blueprint components” (van Merrienboer, Clark & De Croock 2002). Those blueprint components are learning tasks, supportive information, procedural information, and part-task practice which will be briefly explained below.

Learning tasks refer to meaningful whole-task engagements based on real-life scenarios to foster schema construction of non-recurrent aspects of the complex cognitive skill (van Merrienboer & Kester, 2014). Corresponding instructional methods are directed to induction which refers to mindful abstraction from concrete tasks (van Merrienboer, Clark & De Croock 2002).

Supportive information is about the type of information that mitigates the problem-solving or reasoning aspects of the learning task (van Merrienboer & Kester, 2014). It hints at how to approach problems in the domain and how the domain is organized in terms of mental models (van Merrinboer, 2019). Additionally, it serves as a bridge between learners' prior learning and the learning task at hand. Corresponding instructional methods are directed to elaboration which refers to exaggerating the schemata by forming intentional relationships between novel elements and what learners already know (van Merrienboer, Clark & De Croock 2002).

Procedural information involves prerequisites for learning and performing the routine aspects of the learning task (van Merrinboer, 2019). Such kind of information forms an algorithmic guideline for how to carry out such routine tasks. It should be organized as bit-sized knowledge units and should be introduced to learners just-in-time (van Merrienboer & Kester, 2014). Corresponding instructional methods are directed to the compilation which refers to inserting the procedural information into the rules (van Merrienboer, Clark & De Croock 2002).

Lastly, the part-task practice entails extra occasions of practice addressing certain routine or recurrent aspects of the learning task. These practices provide the learner with a vast amount of repetition that can result in a high level of automaticity (van Merrinboer, 2019). However, part-task practice is only necessary when learning tasks fail to enable sufficient opportunities for performing routines (van Merrienboer & Kester, 2014). Corresponding instructional methods are directed to rule automation which refers to compilation followed by reinforcement to achieve automaticity (van Merrienboer, Clark & De Croock 2002).

After a brief overview of the 4C/ID model, it is obvious that van Merrienboer (1997) provides a comprehensive framework grounded in cognitive psychology and thence suggests certain heuristics or principles to form a training strategy. It is important to note two aspects of the model for its relation to the current study. Firstly, several publications from the author, including the original book (van Merrienboer, 1997), do not have direct or even indirect references to the case of technical training although the original book is titled “A Four-Component Instructional Design Model for Technical Training”. Extensive definitions and suggestions are mainly centered around the teaching of complex cognitive skills without specification of technical training. Secondly, the model has a firm theoretical background that relies on many cognitive concepts or mechanisms to convey its premises and suggestions. Therefore, it might be concluded that prior knowledge and experience of learning sciences, as well as a general understanding of related cognitive processes, are preconditions to utilize the 4C/ID model.

2.3.4 Clark’s Approach in Developing Technical Training

Clark's (2011) approach is not an instructional design model, as she puts it, it is rather a “development guideline”. A brief comparison of the guideline and the 4C/ID model can be made to put the former into perspective. van Merrienboer's (1997) 4C/ID model takes an intermediary position in terms of being descriptive or prescriptive. On the other hand, Clark's (2011) guideline is highly prescriptive in that manner. Both approaches are grounded in a firm scientific baseline. However, the 4C/ID model focuses on cognitive mechanisms underlying learning processes whereas Clark's (2011) guideline is centered around utilizing specific instructional methods or principles with empirical evidence. Lastly, interpretation of the 4C/ID model necessitates an understanding of learning sciences as well as cognitive psychology while Clark's (2011) guideline requires little to no prior knowledge of these fields thanks to its plain and goal-oriented approach. In brief, Clark's (2011) technical training development guideline is built upon two defining characteristics: a) evidence-based suggestions and b) straightforward and clear prescriptions.

First of all, Clark (2019) accurately identifies the surprisingly large gap between the scientific literature of training and common practices of the training community. It is possible to observe widely-adopted methods or practices that are not empirically supported (Carliner, Zhao, Barstow, Khoury & Johnston, 2006). Training professionals are inclined to follow traditional customs without questioning their foundations. Therefore, so-called “training myths”, which are baseless and invalid beliefs about training design and delivery, are taken for granted by the majority of the practitioners in the field (Clark, 2019; Hannum, 2009a, 2009b). Accordingly, Clark's (2011) technical training development guideline includes suggestions supported by her two series of publications; one addressing the cognitive underpinnings of training and performance improvement (Clark, 2008), and the other one addressing evidence-based instructional methods and principles (Clark, 2019).

Second to being evidence-driven, Clark's (2011) technical training development guideline is plain and prescriptive. The guideline is a walkthrough for the training designer and it addresses common workplace settings and concerns. Clark (2011) initially lays the foundation for the guideline by introducing four main components of instruction that are common in almost every ISD model. The main components are content, objectives, instructional methods, and delivery media. The guideline explains the technical training design in terms of interventions, decisions or principles regarding these four components. While presenting the main components, Clark (2011) addresses two important issues that are generally neglected in the course of training design (Combs & Davis, 2010; Phillips, 2010). Clark (2011) strongly emphasizes that training occurs in the workplace and hence it has to be a business case as well as an instructional event (Cartwright, 2003). Correspondingly, technical training should be designed in line with bottom-line business goals and, as Clark (2011) puts it, this should be concerned beforehand not as a post-instruction stage as depicted in many ISD models. Another issue that was not overlooked in the guideline is the fact that most training operations, especially in the case of technical training, involve “occasional trainers” (Stolovitch & Keeps, 2014). Those people are subject matter experts with a qualified track record in their respective field and they are occasionally asked to design or teach training courses (Sugar & Schwen, 1995). However, occasional trainers experience major difficulties in designing training or even understanding the basics of instructional design (Williams, 2001). Therefore, Clark's (2011) approach to technical training design acknowledges the involvement of occasional trainers and presents its suggestions in a well-structured straightforward fashion that guides the training designer step by step. The guideline does not require any prior knowledge of ISD models, cognitive psychology, or learning sciences in general. Clark (2011) defines the steps of training design for the designer, highlights the most important and common decisions to make, underlines the most frequently made mistakes, offers actionable suggestions, and provides examples from business settings.

Clark's (2011) technical training development guideline is based on a simple yet effective rationale. The guideline suggests that all training content can be classified using five types of knowledge and each type of content should be taught differently. Differences, suggestions and examples for each type are explained in terms of four main components of instruction: content, objectives, instructional methods and delivery media. The guideline follows this subtle approach to walk the training designer through the course development process.

For this purpose, Clark (2011) proposes a tool for content classification that is adapted from Merrill's (1983) Performance-Content Matrix which was suggested as a part of the Component Display Theory.

2.3.5 Merril's Performance-Content Matrix

It was Gagne (1965) who originally postulated that there are different categories of learning outcomes each of which requires a different approach in terms of instruction and assessment. Subsequently, Merrill (1983) devised his component display theory based on this premise. The component display theory, or CDT, is an attempt to integrate the knowledge of learning and instruction and it primarily focuses on the cognitive domain (Reigeluth, 1983). According to Reigeluth & Merrill (1978), instructional variables can fall into three categories such as organizational strategies, delivery strategies, and management strategies. Organizational strategies refer to decisions regarding the design of learning activities and they can be either micro or macro-level strategies. Micro-level strategies examine the individual displays and their characteristics whereas macro-level strategies deal with selecting, sequencing, and structuring topics to be presented in the instruction (Reigeluth & Merrill, 1978). From this perspective, the CDT is concerned with micro-level strategies for effective instruction (Reigeluth, 1983).

The main assumption of the CDT is that each probable pair of "learner – instructional objective" has a unique combination of primary and secondary presentation forms. These forms are introduced by the CDT. Accordingly, the CDT classifies learning objectives based on two dimensions: a) type of content and b) desired performance on that particular content (Merrill, 1983). Levels of desired performance reflect Gagne's (1985) three cognitive domains such as verbal information, intellectual skills, and cognitive strategies. Thence, the approach of CDT to instructional design translates into a 3x4 sized, two-dimensional matrix called the "Performance-Content Matrix" as illustrated in Figure 2.5. The matrix is named with respect to its dimensions and it suggests expressing learning objectives in the form of performance-content duos.

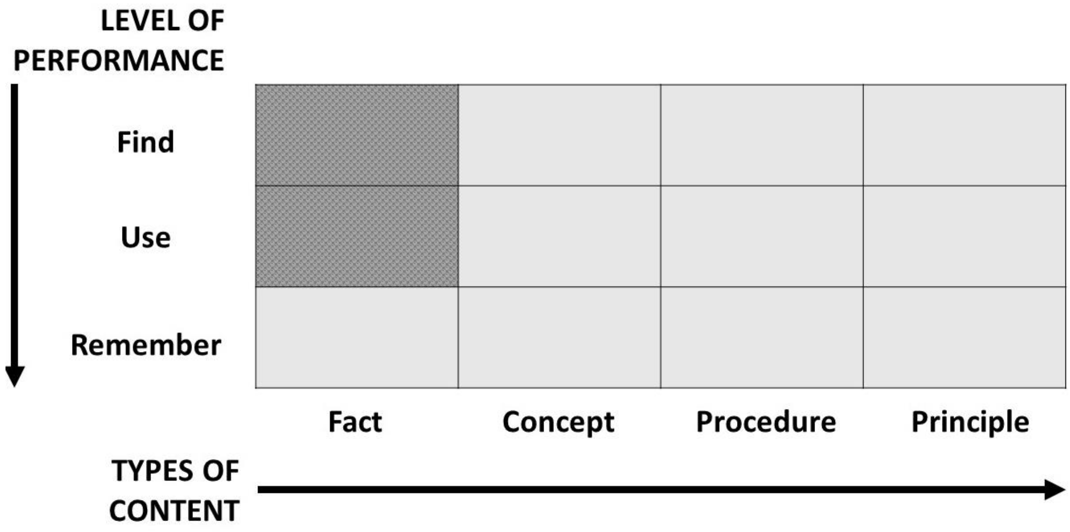

Figure 2.5. Performance-content matrix from Merrill (1983)

The CDT approaches instructional design as a combination of selections or decisions made concerning three taxonomies such as subject-matter taxonomy, performance taxonomy, and presentation taxonomy. Taxonomies are briefly explained below.

Merrill (1983) asserts that there are four types of learning content and elaborates on each one (subject-matter taxonomy). These are facts, concepts, procedures, and principles. Facts are arbitrarily linked bits of information whereas concepts are collections of objects, events, or symbols that have common attributes and they can be identified by the same name. Procedures, on the other hand, are sets of steps in a specific order which should be followed to accomplish a particular objective. Lastly, principles are statements of relationships that interpret or predict the course of action in a system (Merrill, 1983).

These types of content can be taught addressing three different levels of performance such as remembering, using, and finding (performance taxonomy). The remembering level refers to recalling a certain piece of information that was stored in the learner's memory beforehand. The using level involves applying some kind of abstraction to a particular case. Lastly, the finding level implies the performance of deriving or creating a new type of abstraction (Merrill, 1983).

Hence, each learning outcome or testing item falls into a cell of the performance-content matrix. The third pillar of the CDT is the presentation taxonomy. Merrill (1983) suggests that each subject matter can be represented as a function of two dimensions: a) specificity of the content and b) expected response from the learner. In a nutshell, subject matter can be presented as a generality or an instance. It can also be taught in an expository (showing, telling, etc.) or inquisitory (application, completion, etc.) manner. Primary presentation forms are derived by combining levels of these two dimensions. On the other hand, secondary presentation forms are elaborations of primary presentation forms that are generally utilized to provide contextual background (Merrill, 1983).

In the conclusion, the CDT claims that effective instruction can be achieved through selecting a specific presentation form that corresponds to a specific cell in the performance-content matrix.

2.3.6 The Content-Performance Matrix

Clark's (2011) guideline for developing technical training depends on the content-performance matrix as the primary instrument for decision-making in training design. Clark (2011) states that the matrix is a practical and concise tool to guide instructional designers, especially inexperienced ones, in developing effective instruction. The content-performance matrix and the action verbs associated with each cell are presented in Figure 2.6.

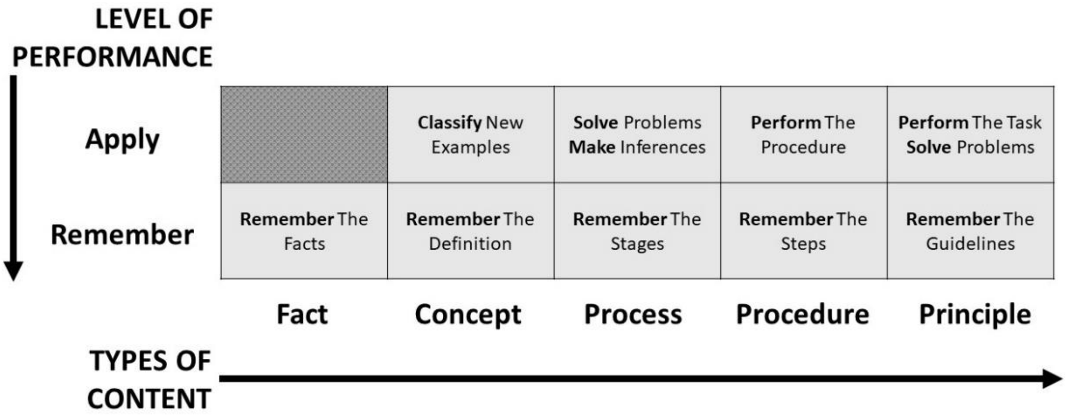

Figure 2.6. Content-performance matrix from Clark (2011)

The content-performance matrix is an adaptation from Merrill's (1983) performance-content matrix (See Figure 2.5). Clark (2011) has made three major modifications to Merrill’s work. First of all, Clark extended the content type dimension by introducing the “process” type. Most of the workforce training content is comprised of procedures and their related facts or concepts. However, employees frequently execute their tasks without realizing how their work fits into the larger picture. Lack of perspective can even negatively affect performance. The knowledge of the processes plays a key role in fixing this problem. The importance of the awareness and comprehension of processes has gradually increased in line with the rise of knowledge work (Clark, 2011). Therefore, Clark suggests including processes in the matrix. The second structural change in the matrix is the refinement in the performance dimension. Merrill's (1983) performance-content matrix has three levels of performance whereas Clark's (2011) version of the matrix has only two levels. Both matrices have the remember level in common. On the other hand, Clark merges “find” and “use” levels into a single level called “apply”. Although Clark (2011) does not explicitly states the underlying rationale for this preference, the reduction of levels in the performance dimension might be associated with the practicality concern that is repeatedly emphasized in the guideline. The third and last difference in the new version of the matrix is related to what is provided for each cell. Merrill (1983) provides his instructional suggestions for each cell of his matrix in terms of presentation forms while Clark (2011) suggests strategies and principles for each cell addressing the selection of instructional methods, writing learning objectives, and evaluating the learner. Hence, it can be concluded that the content-performance matrix is significantly different from the performance-content matrix with respect to structure and functionality. Nonetheless, the prescriptive nature of the tool is preserved in the adapted version as well.

Clark (2011) introduces different and more detailed descriptions for content types which are inherited from Merrill's (1983) work. She also provides several examples from the workplace for each type of content. According to Clark (2011), the procedure is the most substantial content type for workplace learning since skill acquisition is at the core of training and it typically requires performing a procedural task with a particular level of efficiency. A procedure is a set of clearly defined actions that leads to the completion of a specific job task such as running a cyber security scan on a computer or conducting safety controls before starting a machine. Procedures can be linear or they can have branches based on certain decisions. The application level is expectedly vital for procedure-type content.

Clark (2011) states that facts and concepts are complementary parts of procedure-type content. The teaching of associated facts or concepts is often neglected although they are crucial in teaching procedural tasks. Facts can be described as unique, one-of-a-kind information pieces. Therefore, they require a different approach in contrast to other types of content and they can only be performed at remember level. Concrete objects like a particular equipment, unique data like the size of an equipment or association statements like an expression of the number of orders received in a month are examples of facts. Unlike facts, concepts are not unique information. They are mental models of things or ideas that include a number of different examples. All instances of a concept share common characteristics which help the learner to identify and distinguish it from non-examples. Concepts can be either concrete or abstract. For instance, the keyboard is a concrete concept while the performance system is an abstract concept.

Process type is one of the major contributions of Clark (2011) to the matrix. Processes are inherently descriptive in contrast to the prescriptive nature of procedures. They are explanations of how a particular system or mechanism works. They involve the information of how components within a structured framework interact with each other. For example, employee hiring stages in an organization constitute a process. A supervisor needs to understand this process in order to perform certain managerial tasks such as team building or manpower planning. Processes should be taught when a certain performance requires prediction, analysis or troubleshooting within a system. A unique concern for process-type content is to determine the level of specificity based on the conditions. Processes can be presented briefly or in a highly detailed fashion depending on the learning objective and the subject matter.

The last content type in the performance-content matrix is the principle. Clark (2011) places a special emphasis on principle-type content. Although procedural content is fundamental in the workplace, not all job tasks are achievable by predetermined, fixed procedures. Especially, job tasks with greater added value tend to be principle-based. Because the context and conditions of a task are often dynamic and the learner is required to adjust accordingly. Clark (2011) asserts that the shift from automated work to knowledge work is reflected in workforce training as a shift from procedural tasks to principle-based. Clark (2011) also underlines that principle type content is the key for far-transfer occurrences. A principle is a directive that guides the learner on how to adapt to certain conditions in order to achieve a specific goal. Therefore, principles are about following guidelines. For instance, conducting financial analysis is an example of a principle-based task. Since they require the analysis of a given situation and adaptation to it, teaching principles is more challenging compared to other content types (Clark, 2011).

Clark (2011) utilizes two levels for performance dimension: remember and apply. Each content type is assumed to be taught addressing both levels with the exception of facts which can only be taught in remember level. Remember level refers to recalling a certain group of information that is learned beforehand. Only the type of information varies based on the content type. On the other hand, apply level has considerably different implications for each type of content. It can refer to the act of classification for concepts whereas it requires solving a complex problem in the case of principles.

The content-performance matrix can be utilized to create learning outcomes by identifying the type and level of expected behavior. However, Clark's (2011) matrix is beyond an instrument for taxonomy since her guideline fills each cell with corresponding instructional methods, presentation displays, assessment types, and workplace examples. In this way, the instructional designer is provided with an end-to-end solution starting from writing learning outcomes to the evaluation of performance.

2.4 Training Evaluation

The evaluation is a natural ring in the chain of any instructional process. However, there is a unique meaning embedded in evaluation activities in the training context. In formal education settings, either k12 or tertiary level, the whole system is built for instructional purposes. Although evaluation activities are crucial, their results are only used for improving the efficiency of the system. On the other hand, training evaluation has an existential role for training departments. Because the ultimate goal of instruction in the workplace is to create added value that is in line with business objectives. If that is not the case, the very existence of the training system is likely to be questioned (Phillips, 2010, pp. 397-398). According to Kelly (2009), there are three reasons that convince organizations to run a training department: a) to increase revenues b) to improve employee productivity, and c) to increase customer satisfaction and loyalty. Thereby, evaluation of training activities should be dedicated to showing that training programs produce results that comply with at least one of three expectations. In the case of technical training, it is possible to associate training outputs with business goals in a more direct and frequent way (Combs & Davis, 2010; Twitchell, Holton & Trott, 2000). Because the content of technical training concentrates on operational skills that can make difference in terms of organizational goals (Swanson & Holton, 2001).

Although evaluation is an inherent component in the instructional process, it is often perceived and positioned in a non-ideal way. Instructional system design models are inclined to place the evaluation activities at the end of programs and therefore they lead designers to overlook the benefit of pre-program evaluation considerations (P. P. Phillips, 2010). The ADDIE model, the most generic and widely practiced approach to instructional design, reflects that tendency as well. Kirkpatrick & Kirkpatrick (2016) argue that evaluation should not be considered as a final stage but instead, it should be part of each design stage. They suggest that the ADDIE model should be denoted as "A_e D_e D_e I_e E_e" in order to highlight the formative nature of evaluation. Perceiving evaluation as a post-program activity can cause failure in addressing the alignment between instructional objectives and organizational objectives.

Another issue regarding training evaluation is the depth and focus of the evaluation. Many training departments tend to report metrics such as the number of courses delivered, the number of participants who completed a program, or average hours spent in training. However, these types of measurements are not relevant in terms of strategic gains like revenue, productivity, or customer satisfaction (Combs & Davis, 2010). As a differentiator between formal education administration and training management, training leaders are expected to fill in the gaps between organizational goals and training objectives through evaluation. It is also a common mispractice to limit the evaluation to reaction level or learning level (so-called level 1 and level 2 respectively) with respect to Kirkpatrick's (1959) training evaluation model (Catalanello & Kirkpatrick, 1968; P. P. Phillips, 2010). Positive findings in terms of participants' reaction to the program and their achievement levels are not sufficient to demonstrate that the training program enabled far transfer and thence affected bottom-line objectives. The focus of training evaluation should always be measuring and reporting metrics which are indicators of improvement in work performance (Twitchell, 1997).

Kirkpatrick & Kirkpatrick (2010) concisely summarizes that effective training and training effectiveness should be complementary concerns for all training managers. Effective training refers to the successful imparting of content whereas training effectiveness is about the application of content that results in the accomplishment of job-related objectives.

2.4.1 The Kirkpatrick Model

Training evaluation has been addressed by many models and approaches since the 1950s. Among many different models, one of them has pioneered the field and turned out to be the most common evaluation model so far (Combs & Davis, 2010). Kirkpatrick's (1959) four levels of evaluation has been an integral part of systematic training for decades. Although the model has been subject to criticism (Giangreco, Carugati & Sebastiano, 2010), it prevailed over other approaches due to its straightforward and analytic nature (Kirkpatrick & Kirkpatrick, 2016). The model was updated by the successors of Donald Kirkpatrick in order to comply with the contemporary business context. The updated model was called "The New World Kirkpatrick Model". However, the revision of the model focused on addressing common misinterpretations rather than suggesting structural changes (Kirkpatrick & Kirkpatrick, 2016).

Donald Kirkpatrick penned four articles for ATD with titles: "Reaction", "Learning", "Behavior" and "Results". Afterwards, these four keywords gradually became to be known as "Four Levels" (Kirkpatrick & Kirkpatrick, 2016). The four levels resemble the first of two main characteristics of the Kirkpatrick Model, that is, the question of "to what extent a training program should be evaluated?" The model provides a structured approach to answer this question for different cases. According to Kirkpatrick (1959), the extent of evaluation for a training program depends on the relative importance and the amount of investment allocated to it. Upon processing these inputs, the four levels can be used as a guide to determine the degree to which the evaluation should be implemented. For a modest and quick course, level 2 can be an appropriate depth of evaluation while level 4 evaluation would be a must for a comprehensive, year-long curriculum. Hence, the Kirkpatrick Model can be used as a tool to adjust the evaluation strategy. The second characteristic aspect of the model is its hierarchical structure. The Kirkpatrick Model implies a hierarchical relationship between four levels. First, the participants should react positively to learn the content. If they learn the content sufficiently then they can express it behaviorally which will likely produce effects on business objectives (Giangreco, Carugati & Sebastiano, 2010). It can be concluded that the model might be considered as a "hierarchical scale" that measures the depth of the training evaluation and a "prescriptive guide" that walks the professionals through the stages.

Donal Kirkpatrick has devised his model based on five foundational principles that are elaborated below.

Principle 1

Training evaluation should start before the actual program is initiated. Kirkpatrick (1959) states that trainers must initially consider organizational results and then it should be decided that what type of behaviors can produce those results. Subsequently, knowledge, attitude, and skills which can form those behaviors should be determined. Finally, trainers should design how to present the content in an engaging way. The Kirkpatrick Model requires thinking in reverse order.

Principle 2

The value of training programs is indicated by what is called Return on Expectations, or ROE. The ROE is a measure of how well the expectations of organizational stakeholders are met by a training program (Kirkpatrcik & Kirkpatrick, 2014). It is crucial to learn and clarify what the success of a program would look like according to the stakeholders. Trainers should determine indicators for each level by consulting with the stakeholders before proceeding to the design phase (Kirkpatrcik & Kirkpatrick, 2014).

Principle 3

A strong business partnership is required in order to achieve a positive ROE. Many trainers stop at level 1 or level 2 results. However, the ROE can only be created by transcending level 2. Trainers should have a reasonable execution plan to involve supervisors or relevant business partners before the program begins. They are the people who are expected to reinforce newly learned knowledge or provide opportunities to apply newly learned skills. Therefore, a training evaluation plan must address how to relate with business partners (Kirkpatrcik & Kirkpatrick, 2014).

Principle 4

The added value must be created before it can be shown. Plenty of research studies

(Swanson & Holton, 2001; Twitchell, Holton & Trott, 2000; Williams & Nafukho, 2015) consistently report that organizations generally limit their evaluation to level 1 and level 2 and most of the resources are spent on the initial two levels. On the other hand, the ROE and added values are generated by level 3 and level 4. Accordingly, trainers should concentrate on pre-training and follow-up activities (Kirkpatrcik & Kirkpatrick, 2014).

Principle 5

The created value must be demonstrated and the demonstration should be done by means of a chain of evidence that can be produced by using the Kirkpatrick Model. The model enables the trainer to come up with quantitative and qualitative data at each level. Thus, a chain of evidence emerges as the process furthers (Kirkpatrcik & Kirkpatrick, 2014).

Foundational principles are applied throughout the three main phases of a training initiative which are planning, execution, and demonstration of value (Kirkpatrick & Kirkpatrick, 2016).

2.4.2 Four Levels of Evaluation

The main premise of the Kirkpatrick Model is that training evaluation can be conducted at four different levels. Each level is associated with different types of variables and each level requires different data collection and analysis strategies (Kirkpatrcik & Kirkpatrick, 2014). An overview of the four levels of training evaluation is presented in Figure 2.7.

STAGE	NAME	KEY CONCEPTS	RELATED TO:
Level 1	Reaction	Engagement Relevance Customer Satisfaction	Effective Training
Level 2	Learning	Knowledge Skill Attitude Confidence Commitment	Effective Training
Level 3	Behavior	Critical Behaviors Required Drivers On-the-Job Learning	Training Effectiveness
Level 4	Results	Leading Indicators Desired Outcomes	Training Effectiveness

Figure 2.7. Four levels of training evaluation in the Kirkpatrick Model

Each level will be discussed in detail in the following subsections.

Level 1: Reaction

Reaction level is about measuring how favorably participants react to the training activity. The New World Kirkpatrick Model suggests that reaction level is comprised of three dimensions such as engagement, relevance, and customer satisfaction (Kirkpatrcik & Kirkpatrick, 2014).

Engagement refers to active involvement and contribution of participants in a training program. The level of engagement is closely linked to the emergence and quality of learning in the next level (Kirkpatrick & Kirkpatrick, 2016). The second dimension, relevance, is a measure of the likelihood of using and applying what is learned from the training in the workplace (Kirkpatrick & Kirkpatrick, 2016). The perception of relevance is extremely important in enabling higher levels of efficiency in training. Finally, customer satisfaction, or participant satisfaction as used in original Kirkpatrick (1959), is a part of reaction level evaluations.

Reaction level is typically the most practiced evaluation level across organizations. Different studies reported high percentages of level 1 evaluation conducted, ranging from 72% to 92%, and the percentage of implementation was reportedly decreasing towards higher levels (ASTD, 2009; Swanson & Holton, 2001; Twitchell, Holton & Trott, 2000; Williams & Nafukho, 2015). The same pattern applies to the technical training evaluation as well (Swanson & Holton, 2001; Twitchell, 1997; Twitchell, Holton & Trott, 2000). However, Kirkpatrick & Kirkpatrick (2016) highlights that common and frequent implementation of level 1 does not necessarily imply that it is conducted effectively.

Reaction level measurements are oftentimes conducted immediately after the training activity (Kirkpatrick & Kirkpatrick, 2016). Reaction sheets, surveys, focus groups, interviews (Kirkpatrick & Kirkpatrick, 2010), and class observations (Kirkpatrcik & Kirkpatrick, 2014) are the most preferred methods at this level. Reaction level evaluation activities should be quick, cost-efficient, and practical since the data that can be reported from this level is not a significant component of the ROE (Kirkpatrcik & Kirkpatrick, 2014; Kirkpatrick & Kirkpatrick, 2016).

Level 2: Learning

Learning level questions whether the participants acquired the intended knowledge and skills through the training activity. The New World Kirkpatrick Model asserts that the learning level consists of five dimensions such as knowledge, skills, attitude, confidence, and commitment, the last two being the extensions in the updated model (Kirkpatrcik & Kirkpatrick, 2014).

Knowledge dimension is about the degree to which the participants know a certain piece of information whereas skill dimension is about how well participants can perform a specific task (Kirkpatrcik & Kirkpatrick, 2014). Sometimes the organizational problem is not limited to lack of knowledge or skills but it is the absence of intention to act. In such cases, training programs must address participant attitudes as well (Kirkpatrick & Kirkpatrick, 2016). Confidence indicates that how well participants think that they can use what is learned in the training. Addressing confidence issues help finding out potential problems for on-the-job performance (Kirkpatrcik & Kirkpatrick, 2014). Lastly, commitment is the question of whether or not the participants intend to apply what they learned. This dimension highlights that learning of the content should be coupled with an effort to apply it later (Kirkpatrcik & Kirkpatrick, 2014). It can be inferred that knowledge and skill acquisition is the core of learning level evaluation whereas attitude, confidence, and commitment are important enablers for the core expectations.

Learning level is reportedly the second most practiced evaluation level. Its implementation preferences are quite similar to the case of level 1 (ASTD, 2009; Swanson & Holton, 2001; Twitchell, Holton & Trott, 2000; Williams & Nafukho, 2015). A common pitfall regarding the learning level is that many training professionals tend to stop at level 2. Because they believe that they utilized an “above average” evaluation practice by exceeding level 1 (Kirkpatrick & Kirkpatrick, 2010). However, presenting an acceptable ROE case requires at least level 3 results.

Learning level measurements are characterized by exams. Pre-test and Post-test approach is frequently used. Resources allocated to such kind of testing must be balanced with the relative importance of level 2 though (Kirkpatrcik & Kirkpatrick, 2014). Tests are not the only option. Table discussions or game-based measurements can also be utilized depending on the subject matter. On the other hand, participants need to do or demonstrate something for evaluating skill acquisition. Accordingly, practical examinations or projects are common choices for skills evaluation (Kirkpatrick & Kirkpatrick, 2016). Class discussions, Q & A sessions, observations, and reflection activities can be used to evaluate the attitude, confidence, and commitment levels of participants (Kirkpatrick & Kirkpatrick, 2016).

Learning level evaluation activities should be focused on. Training professionals should ensure that level 2 examinations are centered around job-related knowledge and skills rather than general concepts or detailed literature (Kirkpatrcik & Kirkpatrick, 2014; Kirkpatrick & Kirkpatrick, 2016).

Level 3: Behavior

Behavior level is the measure of how effectively participants utilize what they learned during the training activities when they get back to work (Kirkpatrcik & Kirkpatrick, 2014). The New World Kirkpatrick Model states that the behavior level is comprised of three dimensions such as critical behaviors, required drivers, and on-the-job learning (Kirkpatrcik & Kirkpatrick, 2014).

Critical behaviors refer to particular actions which are likely to have the greatest impact on desired outcomes. The most characteristic aspect of critical behaviors is that there is a limited number of them for each case (Kirkpatrcik & Kirkpatrick, 2014). It is difficult to determine the few critical behaviors among many actions related to a given task. Critical behaviors should be specific, measurable, and observable so that one can record the action and then explain what is going on (Kirkpatrick & Kirkpatrick, 2016). Thus, evaluators can observe, isolate, count, and examine critical behaviors in order to have level 3 findings. The second dimension is required drivers which are systems or processes that monitor, foster, and reward the critical behaviors on the job (Kirkpatrcik & Kirkpatrick, 2014). Required drivers are highly influential in achieving organizational goals through training. Brinkerhoff (2006) showed that a drastic difference emerges when training programs focus on follow-up activities and organizations agree on enabling opportunities along with support for learned behaviors upon completing the training. The study reports 85% application of what is learned compared to 15% when organizations ignored level interventions. After program support could be in form of coaching, mentoring, incentivizing, or reminders (Kirkpatrcik & Kirkpatrick, 2014). Organizational support should be coupled with accountability. Participants should be monitored in terms of learned behavior in an efficient and objective way (Kirkpatrick & Kirkpatrick, 2016). The last dimension is on-the-job learning which is introduced by the updated model in recognition of contemporary business dynamics. The model incorporates the fact that a significant portion of learning occurs on the job and it is driven by personal autonomy and motivation (Kirkpatrcik & Kirkpatrick, 2014).

Kirkpatrick & Kirkpatrick (2016) draws attention to that behavior level is the most important level of evaluation since the existential justification of the training in the organizational structure is generated by level 3 behavioral changes. From this perspective, level 3 is beyond evaluation. It is a substantial, continuous performance monitoring and improvement mechanism as well (Kirkpatrick & Kirkpatrick, 2016). Nonetheless, the training community often neglects level 3. Executives focus on level results while training professionals concentrate on level 1 and level 2 findings. The behavior level is arguably the missing link in producing positive ROE (Kirkpatrick & Kirkpatrick, 2016).

It is essential to utilize pretraining dialogue with executives and determine critical behaviors and required drivers before the program starts. These preparations pave the way for an effective behavior level evaluation (Kirkpatrcik & Kirkpatrick, 2014). Level 3 makes use of several methods or instruments such as post-program surveys, manager interviews, performance reviews, or observation forms (Kirkpatrick & Kirkpatrick, 2010). Organizations should allocate considerable resources to level 3 implementation as it is the key factor in generating positive ROE (Kirkpatrcik & Kirkpatrick, 2014; Kirkpatrick & Kirkpatrick, 2016).

Level 4: Results

Results level is about measuring the degree to which desired objectives are achieved by means of training and post-training reinforcement (Kirkpatrick & Kirkpatrick, 2010). The New World Kirkpatrick Model suggests that the results level has two dimensions such as leading indicators and desired outcomes (Kirkpatrcik & Kirkpatrick, 2014).

Leading indicators are short-term assessments or observations that imply critical behaviors are on course to produce the desired results (Kirkpatrcik & Kirkpatrick, 2014). They provide a connection between the performance of critical behaviors by individuals and the highest level organizational objectives (Kirkpatrick & Kirkpatrick, 2016). Some of the frequently used leading indicators are customer satisfaction, production volume, market share, employee engagement, and service quality (Kirkpatrcik & Kirkpatrick, 2014). Organizations need to be cautious when dealing with leading indicators. Although they are important indicators, the foci should always be on the highest level objectives. For instance, having a reliably increasing production volume does not guarantee that organization will achieve its targeted annual revenue. On the other hand, desired outcomes are a self-explanatory concept. Although level 4 evaluation activities utilize leading indicators, the main focus of the evaluation is to find out whether organizational level desired outcomes are provided (Kirkpatrcik & Kirkpatrick, 2014).

All training activities are arguably conducted to obtain meaningful level 4 findings. Ironically, it is the most misunderstood and misapplied level of evaluation for many organizations (Kirkpatrick & Kirkpatrick, 2016). Generally, inaccurate level 4 evaluations are the product of poor judgments made by professionals in determining their organizational objectives. Managers or supervisors are prone to reflect the goals of their own units as large-scale organizational goals. Thence, level 4 evaluations are based on misalignments (Kirkpatrick & Kirkpatrick, 2016). Another common perception is that level 4 evaluations are considered to be inherently summative. That is why The New World Kirkpatrick Model introduces leading indicators to emphasize that level 4 activities can and should start without waiting for a yearly assessment period (Kirkpatrick & Kirkpatrick, 2016).

It should also be noted that the highest level organizational objectives cannot be altered immediately after the training program. Therefore, results level evaluation activities typically need some time to detect the effect of the intervention. A reasonable timeframe should be decided to examine desired outcomes in collaboration with business partners. Throughout the timeframe, leading indicators must be monitored and assessed. (Kirkpatrick & Kirkpatrick, 2016).

The Summary

Kirkpatrick's (1959) four levels of training evaluation provide a framework to decide the depth of evaluation and also suggest strategies, methods, and instruments for each level. Levels are hierarchically organized and level 4 is the cumulative result of the evaluation activities conducted in previous levels. However, the model underlines that evaluation activities for four levels should be designed in reverse order. Training professionals need to start with determining high-level organizational outcomes and their indicators. Then, critical behaviors which generate these indicators must be decided. Training courses should be designed in order to teach those critical behaviors. The courses should also be presented in an engaging and relevant way. Upon following this reverse sequence of concerns, the focus of the evaluation is driven by the expectations of the organizational stakeholders.

2.4.3 The Learning-Transfer Evaluation Model

Kirkpatrick's (1959) four levels of training evaluation model has spurred a great amount of attention since its introduction back in the late 1950s. But it has also been subject to criticism by many different sources (Brown, 2005; Holton, 1996; Sitzmann, Brown, Casper, Ely & Zimmerman, 2008; Tannenbaum & Woods, 1992). Among many critics, one of them not only criticizes the four levels model but also proposes an alternative model which arguably addresses the criticized aspects of the former. That is Thalheimer's (2018) Learning-Transfer Evaluation Model or LTEM in short. Another important aspect of the LTEM is that it recognizes and embraces the contributions and practicality of Kirkpatrick's (1959) four levels.

Thalheimer (2018) concentrates on how the structural organization of a model shapes the common practices in the field. He suggests that a model should send messages to practitioners so that the most important concerns are highlighted. Accordingly, he develops his rationale by stating 17 messages which are expected to be conveyed by the use of an evaluation model. These messages include items like “engaging is not necessarily learning”, “using effective learning methods does not guarantee learning” or “demonstration of skill in training does not guarantee transfer to the job” etc. Providing that, Thalheimer (2018) states that the Kirkpatrick Model is successful in highlighting on-the-job performance, promoting that learning can improve organizational performance, implying that self-assessment of learners are of lower importance and suggesting that reactions, learning, behaviors, and results are interdependent.

On the other hand, Thalheimer (2018) lists 10 points on which he believes the Kirkpatrick Model sends undesired messages to practitioners. Some of the negative messages are items like “overlooking the importance of post-program reinforcement”, “ignoring other performance support tools in favor of training” and “not discouraging the use of non-relevant metrics”. Consequently, Thalheimer (2018) explains his new model and asserts that it can be used for all kinds of learning interventions.

Thalheimer (2018) points out that the LTEM is a roadmap that needs to be reviewed backward similar to reverse thinking of the Kirkpatrick Model. The model is comprised of 8 levels. Each level reflects a certain maturity in evaluating learning results and half of the lower levels are labeled as “inadequate” for learning evaluation. Levels also define what to evaluate at that stage. Thus, the LTEM walks the trainer to a mature and adequate level of learning evaluation. An overview of the LTEM is depicted in Figure 2.8.

Learning-Transfer Evaluation Model

TIER	NAME	EVALUATION STATUS	RELEVANCE
Tier 8	Effects of Transfer	Adeaquate	Work
Tier 7	Transfer	Adequate	Work
Tier 6	Task Competence	Partially Adequate	Learning
Tier 5	Decision-Making Competence	Partially Adequate	Learning
Tier 4	Knowledge	Usually Inadequate	Learning
Tier 3	Learner Perceptions	Inadequate	Learning
Tier 2	Activity	Inadequate	Learning
Tier 1	Attendance	Inadequate	Learning

Figure 2.8. Learning-transfer evaluation model by Thalheimer (2018)

Each level of the LTEM corresponds to the evaluation of certain variables of interest and the model assigns different volumes of importance to each level. All eight levels are briefly discussed in the following subsections.

Level 1: Attendance

Even though participants' mere participation in a course does not indicate that they have learned the subject, many organizations surprisingly base their training evaluation entirely on attendance (Thalheimer, 2018). Attendance can be in form of signing up, physical presence, starting an activity, or completing any type of learning experience. Apparently, attendance measurements are not adequate in terms of training evaluation. However, that does not imply that attendance metrics should be abandoned.

Level 2: Activity

Activity level encompasses any kind of indicators for participant engagement such as attention, interest, and participation. Activity level measurements could be either formal or informal. For instance, many online platforms recognize the number of engagement activities or instructors may believe that the lesson is on the right track since the collective mood of the participants is engaging and supportive. Activity level could foster certain evaluation biases and therefore it should be handled carefully. However, activity level cannot provide adequate evidence for the occurrence of learning. Because people can show interest, pay attention, or participate but still might not learn (Thalheimer, 2018).

Level 3: Learner Perceptions

It is common to collect data regarding the perceptions of participants about a specific course. Reaction sheets and after-course sessions where the participants are encouraged to share their views about the lesson can be considered as examples of this level. It can be expressed as learner satisfaction of course reputations. Although it is a positive indicator, having favorable perceptions is not causally linked to learning results. Positive perceptions might arise due to factors different that the quality of the learning. Therefore, learner perceptions cannot be accepted as adequate gauges of intended learning outcomes (Thalheimer, 2018).

Level 4: Knowledge

Knowledge acquisition is one of the most commonly practiced aspects of training evaluation. It can be examined immediately after the course or after a certain amount of time. The LTEM states that knowledge recitation is the testing of the acquisition of facts and nomenclature during or right after the learning experience. In contrast, knowledge retention is examining whether participants can recall what is learned after several days or more. Even though knowledge recitation and knowledge retention can provide hints on actual learning they do not fully enable the desired performance. Such types of measurements must be augmented with higher-level evaluation activities (Thalheimer, 2018).

Level 5: Decision Making Competence

Acquiring the knowledge of subject matter is not sufficient to represent all learning outcomes. Most of the time desired behavior involves decision-making. The LTEM highlights that this aspect of learning must be addressed in the evaluation. Decision-making competence can be analyzed two-fold based on the temporal relation to the learning experience, similar to the knowledge level. Decision-making competence throughout or after the training and remembered decision-making several days after the training needs to be evaluated separately. While immediate decision-making competence may fade in time, remembered decision-making competence is an adequate indicator of the acquisition of decision-making skills in that particular subject. However, it is only sufficient within that scope, the entire range of learning outcomes requires further evaluation (Thalheimer, 2018).

Level 6: Task Competence

Task competence is about desired performance. It is also two-fold on the temporal dimension. Immediate demonstration of task competence upon completing the learning event is a powerful indicator. But it is still open to question whether participants can preserve that competence over time. On the other hand, remembered task competence several days after the learning event enables the evaluator to certify the participant as “task competent”. However, this does not imply that participants can transfer the competence into the actual work environment (Thalheimer, 2018).

Thalheimer (2018) suggests that training professionals ensure that the following four stages are implemented in order to measure the task competence: a) presenting near-authentic situations, b) make participants analyze the situation, c) let participants make decisions, and d) have participants take actions based on their decisions. It is also strongly recommended by Thalheimer (2018) that such evaluations must involve experts in the field. Level 6 is a demanding endeavor with a relatively high reward in form of reliable proof for work performance alignment.

Level 7: Transfer

The LTEM suggests that adequate measures of achieving learning outcomes can be obtained starting from this level onward. Transfer refers to the case when participants can use what they learn from the training in order to perform work tasks. According to Thalheimer (2018), there are two types of transfer: assisted transfer and full transfer. Assisted transfer describes the situations where participants transfer what they learn with considerable help such as prompting for the usage of skill, rewarding of performance, coaching, or direct assistance in performing the task. Evaluation of assisted transfer ensures the fact that participants can perform on the job with certain aids. On the other hand, full transfer refers to the performance of tasks in the workplace without any external involvement. Therefore, this type of evaluation is adequate to decide that the participant can apply what is learned in the training in authentic settings (Thalheimer, 2018).

Level 8: Effects of Transfer

Achieving the transfer of learning is the ultimate goal for training activities. Since the introduction of human capital theory (Becker, 1962), learning has been positioned as an instrument to improve organizational performance. The Kirkpatrick Model has reinforced this position successfully by emphasizing the alignment with business objectives. However, Thalheimer (2018) draws attention to the fact that transferred learning might have an impact on different issues along with the desired business outcomes. He asserts that transfer may affect learners, colleagues, and families of learners, the organization, the community, society, and the environment. He states that each learning intervention is likely to produce unintentional or unexpected consequences as well. These consequences can either be positive or negative. For example, a leadership training that achieves transfer and thence affects the organization in the desired way can also alter the life of the learner, his/her subordinates, and the department in a way which is not part of training objectives. Therefore, Thalheimer (2018) suggests that evaluation should not stop upon examining the transfer and other potential impacts of the program should also be inspected.

The Summary

Thalheimer's (2018) Learning-Transfer Evaluation Model can be considered as an installment on the Kirkpatrick Model. The LTEM approaches the training evaluation in a very similar fashion compared to the Kirkpatrick Model. Both models suggest a reverse workflow starting from ultimate goals, levels addressing different depths of evaluation, and a cumulative direction in terms of evaluation evidence. It can be inferred that the LTEM has two significant differences. Firstly, the LTEM utilizes a higher number of levels and splits Kirkpatrick's (1959) levels into smaller pieces. Hence, it proposes a greater sensitivity in the following steps of evaluation procedures. Secondly, the LTEM is characterized by common pitfalls and misapplications in the field of training evaluation. The model frequently underlines misperceptions and presents its suggestions in the form of a "lessons learned" fashion.

CHAPTER 3

METHODOLOGY

This chapter of the dissertation presents the research methodology utilized in the study. It includes research questions, research design, population and sampling, context of the study, data collection instruments, the treatment, data collection procedures, data analysis, role of the researcher, validity and reliability issues as well as limitations.

3.1 Research Questions

The purpose of this study is to examine a technical training design tool based on Clark's (2011) guideline in order to suggest a prescriptive and evidence-based solution for improving a catalog of technical training courses in the same context. Additionally, the present study aims to provide a working example on how to evaluate and associate technical training with organizational objectives. Accordingly, the following research questions are investigated to accomplish the purposes of the study:

1. Does the redesigned course increase post-test achievement scores after adjusting for pre-test achievement scores?
2. Is there a significant difference between the groups in terms of error counts recorded after the course while holding the error counts recorded before the course constant?
3. What is the effect of the redesigned course on trainees' reactions towards training in terms of objectives, content and evaluation aspects?

3.2 Research Design

There is a number of different approaches in terms of classifying scientific research. Distinctions can be made concerning the data characteristics, the overall purpose of the study, and methods of inquiry (Fraenkel, Wallen & Hyun, 2012, pp 7-16). First of all, the present study is a quantitative research since it collects and analyzes quantitative data through mathematical methods (Creswell, 1994 as cited in Sukamolson, 2007). Secondly, this study is an applied research effort regarding the classification by purpose. Gay, Mills & Airasian (2011) states that educational research studies can be distributed on a spectrum with two categories such as basic research and applied research. They elaborate that basic research is carried out solely for developing or refining a theory whereas applied research aims to test an existing theoretical model in order to investigate its effectiveness in real-world settings. Accordingly, the present study is conducted to test Clark's (2011) technical training design guideline in terms of its effect on achievement, learning transfer, and reaction.

The last way of classifying research is focusing on methods of inquiry. From this perspective, this dissertation study employed an experimental research design. The research problem examined in the study essentially focuses on determining how effective the proposed training design approach is in the context of particular organizational settings. A reasonable way of deciding the effectiveness of the proposed approach is comparing it with traditional training design practices. For that comparison, the effect of the proposed approach on dependent variables must be distinguished from the probable effects stemming from other factors. Therefore, the present study attempts to establish causal links between the proposed training design approach and the observed changes in dependent variables. Experimental design is considered one of the most powerful methodologies and it is particularly the best way of establishing cause-and-effect relationships (Fraenkel, Wallen & Hyun, 2012). Additionally, the experimental design enables the researcher to control and manipulate a variable of interest, introduce an intervention and observe the change on dependent variables across groups (Cohen, Manion & Morrison, 2007) which is the required scenario for solving the research problems of the present study.

Although the experimental design is a powerful one, it is also demanding to conduct it in real-world settings because it obliges the researcher to have control over many different conditions (Field & Hole, 2002). Consequently, certain research efforts are categorized as quasi-experimental studies instead of true experimental studies. Quasi-experimental research designs lack the use of random assignment which means that every subject participating in the experiment has an equal chance for being assigned to either the treatment group or the control group (Fraenkel, Wallen & Hyun, 2012). Hence, the availability of random assignment is a distinctive aspect of a true experimental design. Furthermore, Cohen, Mainon & Morrison (2007) suggest that a true experimental research design has to satisfy all of the criteria listed in Table 3.1 which also presents the status of the present study for each criterion.

Table 3.1 True Experimental Design Criteria

Criteria	Status for the present study
Having one or more control groups	Satisfied
Having one or more treatment groups	Satisfied
Random assignment to control and treatment groups	Satisfied
Pretest of the groups to ensure parity	Satisfied*
Posttest of the groups to see the effects on dependent variables	Satisfied
One or more interventions to the treatment group	Satisfied
Isolation, control, and manipulation of independent variables	Satisfied
Non-contamination between the control and treatment groups	Satisfied

* Both control and treatment groups were subject to pretesting and the parity was examined. Pretesting results were then used as a covariate in data analysis though.

It can be concluded that the present study followed a true experimental design since it managed to satisfy all of the criteria summarized in Table 3.1.

A true experimental research design can be carried out in various forms. The variant employed in this study is named in a similar yet slightly different fashion by two separate sources. This particular design is called ”The Randomized Posttest-Only Control Group Design” (Fraenkel, Wallen & Hyun, 2012) or “The Posttest Control And Experimental Group Design” (Cohen, Manion & Morrison, 2007). The design involves the random assignment of subjects to one control group and one treatment group. Subsequently, the treatment group was exposed to a certain intervention which is the redesigned version of an existing course that has already been taught in the Turkish Aerospace Academy prior to the study. The course was redesigned by the researcher with the help of a subject matter expert through following Clark's (2011) technical training design guideline. On the other hand, the control group subjects participated in the original version of the same course. Upon completing their courses, all subjects were administered a reaction sheet and they all took the same achievement test. For the third dependent variable, performance error records of the subjects were retrieved from the organizational systems after the completion of the course.

Table 3.2 depicts the experimental design used in this study based on the terminology provided by Campbell & Stanley (1963).

Table 3.2 Experimental Research Design Employed In The Present Study

Group	Assignment	Treatment	Posttest
Treatment	R	X	O_1
Control	R	C	O_2

The notation used in Table 3.2 can be explained as follows:

R: Random Assignment

O_1: Observation of dependent variable with posttest exam

O_2: Observation of dependent variable with posttest exam

X: Exposure to the redesigned version of the course

C: Exposure to the original version of the course

The same experimental pattern was followed for all three dependent variables.

It should be noted that there was one more occasion of observation for two out of three dependent variables which are achievement and transfer to work performance. All participants took a pretest of achievement that is identical to the posttest. Similarly, performance error records of all participants that span the two months before the course were obtained. Those pretest measurements are not reflected in the experimental research design since it was later decided that pretest scores are likely to be great confounding factors in posttest scores and prior scores of the groups are not significantly different from each other. Therefore, a posttest-only design was employed instead of a pretest-posttest design. This issue will be revisited in greater detail in the data analysis section.

3.3 Population and Sampling

This section summarizes the population of the study, explains the sampling procedure, and finally describes the characteristics of the participants.

3.3.1 Population

Determining the population is a significant milestone in the course of each research study. The population can be evaluated in two different levels. These are; a) the target population which is a specific group of people to whom the researcher would like to generalize in an ideal case and b) the accessible population which is the group of people to whom the researcher can generalize upon completing the study (Fraenkel, Wallen & Hyun, 2012). The present study is planned and conducted within a particular context, that is, a corporate academy of a large-scale aerospace company which designs, manufactures, and assembles various types of aircraft. In this manner, the target population of this study is the entirety of technicians who actively work in the aerospace industry involving manufacturing and assembly operations. On the other hand, the accessible population of this study is comprised of all technicians who work for Turkish Aerospace Inc. at the time of the study. A total of 4238 technicians were working for Turkish Aerospace Inc. while this study was carried out. All of these employees were accessible to the researcher at the time.

3.3.2 Context of the Study

It is necessary to introduce the context of the study before explaining the sampling procedures since certain decisions depend on contextual knowledge. The present study was conducted in Turkish Aerospace Academy that is a corporate academy within the Turkish Aerospace Inc. or TAI in short. TAI is the leading player in the Turkish aerospace sector that designs, manufactures, and assembles a wide range of aircraft platforms including fixed or rotary-wing systems, manned and unmanned systems as well as satellites. TAI has a well-equipped corporate academy that runs an extensive training operation. Turkish Aerospace Academy provides more than 10.000 employees with both technical and social training programs. The present study is particularly interested in technical trainings which correspond to the largest component of the operational volume both in terms of the number of participants and the number of available courses.

Turkish Aerospace Academy offers a catalog of 300 technical courses to 4238 technicians working for the company. Approximately 80% of technical courses are subject to renewal on a periodical basis because technical courses are centered around psycho-motor skills which are likely to fade in time (Romiszowski, 2009). Therefore, it is routine for technicians to take certain courses repeatedly in order to preserve their certified status for particular operations. As a matter of fact, the aerospace industry is highly regulated with very strict rules and it has a very low tolerance for errors. Accordingly, technical trainings are dedicated to ensure that participants acquire or preserve certain sets of motor skills.

Technical trainings in Turkish Aerospace Academy is delivered by 15 full-time instructors and hundreds of part-time instructors. Working conditions and profiles of part-time instructors are perfectly matched with what is called “occasional trainer” earlier in this study (Stolovitch & Keeps, 2014). These are experts with a track record who occasionally design and deliver technical courses in classrooms and application workshops. On the other hand, full-time instructors are people who mostly have pedagogical formation and prior field experience in different departments of TAI.

Technical training catalog addresses a variety of subjects like structural assembly, mechanical systems, electrical systems or chemicals, etc. However, there is a collection of technical courses which should be completed by each TAI technician in order to proceed in their professional careers. These common courses provide foundational knowledge and skills for widely practiced aerospace assembly and manufacturing operations. Technical course load is determined and assigned to the employees by the corporate academy staff. A typical training course load of a technician is composed of both must and optional courses. Optional courses are decided on the basis of flexibility and multi-role policy, that is, each technician is expected to master his/her primary role as well as developing secondary expertise in a closely related branch of operations. The duration of technical courses ranges from

1 hour to 80 hours based on the content and practical exercises. Courses are 8 hours long on average and each session is typically implemented with 20 participants.

3.3.3 Sampling

The sampling procedure followed several stages that utilize different sampling strategies. The selection of the participants was preceded by determining a course from Turkish Aerospace Academy technical training catalog.

It was necessary to identify a course which is a must for as many technicians as possible in order to ensure that the pool of prospective course-takers would be highly representative of the properties of the population. Accordingly, a course entitled "General Solid Rivet Application" was selected as the target course of the study. Solid rivet application is a fundamental operation which is the most frequently practiced one across different departments. Correspondingly, the selected course is part of the course load for the majority of the technicians. The course was a must for 2628 out of 4238 technicians (62%) at the time of the study. In addition, the course is optionally offered for another 1125 (26.5%) technicians who work in indirectly related departments. Hence, a total of 3753 technicians, 88.5% of the accessible population, were eligible to take the course.

At the time of the study, 658 technicians were queued up to take the selected course. The rest of the prospective course-takers either completed the course beforehand and their renewal period had not expired yet or a course request had not been created yet. However, the researcher did not limit the selection pool to queued-up employees. Instead, all eligible technicians (N = 3753) were included in the further sampling processes in order to increase the likelihood of having a sample that reflects the characteristics of the population. When the final participant group was assembled, 9 of them were the ones who did not have to take the course until a considerably later date. However, all of these participants voluntarily admitted to taking the course before their actual expiry date and necessary arrangements were orchestrated by the researcher in terms of quality and certification monitoring systems.

The selection of the target course for the study could notably alter the number of eligible employees within the accessible population. Therefore, the decision was made with the intention of keeping the sample relevant to research problems and research design based on the criteria explained under section 3.5.2 Original Course.

In the conclusion, 88.5% of the accessible population (N = 3753) was qualified as available candidates for participant selection after the target course was determined in the first stage of sampling. Table 3.3 explains the first stage of sampling that is conducted in a criterion-based manner.

Table 3.3 First Stage Of Sampling Through Target Course Selection

Group of interest	N	% Of Accessible Population
Target population: Entirety of aerospace industry technicians	Uncertain	N/A
Accessible population: TAI technicians	4238	100
Eligible TAI technicians for the selected course	3753	88.5
TAI technicians who are required to take the selected course	2628	62
TAI technicians who can optionally take the selected course	1125	26.5

Before proceeding to the second stage of sampling, it is important to note some concerns. To begin with, it is crucial to determine the sample size before undertaking actual research efforts. The sample size should be decided considering the statistical analyses to be used, the number of variables, and the kind of relationships intended to be explored (Cohen, Manion & Morrison, 2007, p. 101). The sample size for the present study was determined as 120 concerning these factors. Statistical tests were clarified upon the overall research design was decided. Thence, the required sample size was calculated based on the selection of statistical tests and variables of interest. This issue will be revisited in greater detail in data analysis section.

Another concern is related to certain properties of the population. A series of meetings were held with full-time academy instructors and certain occasional trainers who are highly familiar with the organization and the accessible population. These experts drew attention to three aspects of the accessible population profile with respect to the selected course. First of all, the importance of educational background was highlighted in solid rivet operations which requires sharp motor skills. Experts stated that they have observed in years of experience that people with a vocational background, particularly graduation from a vocational high school, tend to learn and replicate required skills faster and more effectively. Secondly, they emphasized that relevant work experience can play a role in achieving the objectives of the selected course because experienced technicians are more likely to have an advantage in comprehending and applying the content. As the third factor, it was also discussed that taking the course first time or as a renewal might also lead to a difference.

In the second stage of the sampling, an approach that is similar to simple random sampling was employed. In order to conduct simple random sampling, a researcher must ensure that each member of the population possesses an equal and independent chance of being selected (Fraenkel, Wallen & Hyun, 2012). In this case, simple random selection was applied to the eligible 88.5% of the accessible population (N =3753) instead of the target population. For that purpose, the name list of 3753 eligible technicians was initially saved in a Microsoft Excel file with incremental index numbers for each row. Then, an array of 120 random integers between 1 and

3753 was created through a combination of four different random number generation algorithms. Two pseudo-random number generator functions and two true random number generator services were used together. Table 3.4 presents the random number generation methods.

Table 3.4 Random Number Generation Methods

Function or algorithm	Type	Baseline
Microsoft Excel: Randbetween() Function	Pseudo-Random	Programming Language
Java: Math.Random() Function	Pseudo-Random	Programming Language
Random.org: Integer Series Generator	True Random	Atmospheric Noise
Random.org: List Randomizer	True Random	Atmospheric Noise

Four arrays of 120 random integers were generated. For each of 120 rows, another integer between 1 and 4 was generated through Microsoft Excel Randbetween() function in order to decide which one of four indexes will be used in the final array. In this way, an eventual array of 120 integers ranging between 1 and 3753 was composed. Afterwards, the employees with index numbers included in the final array were extracted from the Microsoft Excel file. In this way, 120 employees from the eligible 3753 technicians were determined randomly. Lastly, the list was split in half. The first half was assigned to the control group whereas the last half was assigned to the treatment group.

The eventual group of 120 employees was considered as the tentative sample until the group is examined in terms of three properties highlighted by the experts. The tentative sample was reviewed in terms of the distribution of educational background, relevant work experience, and prior exposure to the selected course across the experimental groups. The intention was to regenerate the list if the final group was distributed in an unbalanced way in terms of three characteristics. If the second attempt of random selection had failed too, a stratified sampling approach would have been employed. Fortunately, it was observed that three characteristics were distributed fairly balanced for both control and treatment groups. Therefore, it was decided to use the randomly generated list as the basis of the eventual sample of the study.

3.3.4 Participants

The participants of this study are TAI technicians who are consistently or occasionally required to perform structural assembly and manufacturing operations. They are selected for the study as a result of their job descriptions which renders them the target audience of a particular technical training course.

The age of participants ranged between 19 and 41with a mean of 27.83 and a standard deviation of 4.38. Table 3.5 shows the descriptive statistics for participants' ages.

Table 3.5 Descriptive Statistics For Participants' Ages

Age	*n*	%
19-25	42	35
26-30	50	41.6
31-35	20	16.7
36-41	8	6.7

When the ages of the participants are examined across experimental groups, it is observed that means of both groups are close to each other. While the control group had a mean age of 27.78 (*SD*=4.53), the mean for the treatment group was 27.88 (*SD*=4.26).

The sample of the study was uniform in terms of gender as all participants were males (n=120). At the time of the study, only 46 (1.1%) out of 4238 TAI technicians were women. The ratio of female technicians was even lower among technicians who were eligible for the selected course, that is, 2 out of 3753. The gender bias in terms of employment in manufacturing jobs is a globally known issue (World Bank, 2019). Correspondingly, women were insufficiently represented within the accessible population and it turned out that neither of the two eligible women technicians was selected as a result of random indexing.

As Table 3.6 shows, technicians with a vocational education background account for the majority of the participants (73.3%, n=88). These employees had either vocational high school degrees or degrees from technical vocational higher education. The rest of the participants (26.7%, n=32) had degrees from other types of schools. The distribution in favor of vocational education graduates is a direct result of the organizational recruitment policy which prioritizes vocational education over other qualifications.

Table 3.6 Education Level Distribution

Educational background	Control group		Treatment group		Total sample	
	n	%	n	%	n	%
Vocational	46	77	42	70	88	73
Other	14	23	18	30	32	27

The prevalence of vocational education graduates is preserved across experimental groups. 77% (n=46) of the control group had vocational education background whereas 70% (n=42) of the treatment group had vocational education degrees.

Participants' work experience relevant to the subject matter of the selected course varied between 1 and 19 with a mean of 5.75 and a standard deviation of 4.37. Table 3.7 shows the descriptive statistics for participants' relevant work experience.

Table 3.7 Descriptive Statistics For Relevant Work Experience

Relevant work experience	Control group		Treatment group		Total sample	
	n	%	n	%	n	%
0-5 Years	35	58	27	45	62	52
6-10 Years	18	30	23	38	41	34
More than 10 years	7	12	10	17	17	14

It is observed that slightly more than half of the participants (52%, n=62) had 5 years or less work experience related to the subject matter which is solid rivet application. It is an expected distribution considering that the organization recruited large numbers of new graduates in recent years. It should be noted that relevant work experience was calculated by filtering the departments and workstations of participants. Certain workstations and departments were marked as relevant by experts from the Turkish Aerospace Academy. Experience years spent on unmarked stations or departments were excluded for each participant.

In comparison of experimental groups, the control group had 58% (n=35) 0 to 5 years experienced participants and the treatment group had 45% (n=27).

Lastly, participants of the study were examined considering whether or not they had taken the selected course before. The course selected for the study was a repetitive one. Technicians were required to complete the course every 5 years in order to preserve their certified status in solid rivet operations. Table 3.8 shows that 52% of the participants (n=62) took the course the first time whereas 48% of them completed the course before at least once.

Table 3.8 Distribution Of Prior Exposure To The Selected Course

Prior exposure to course	Control group		Treatment group		Total sample	
	n	%	n	%	n	%
First time	35	58	27	45	62	52
Renewal	25	42	33	55	58	48

As noted earlier, 9 out of 120 participants (7.5%) were not obliged to take the course at the time of the study. They still had time until their certificates in solid rivet application expire. However, they voluntarily agreed to participate in the study and take the course in advance.

3.4 Data Collection Instruments

The data for the present study was collected through three different instruments which are the pre-course achievement test, the post-course achievement test, and The New World Level 1 Reaction Sheet. In addition, certain pieces of data were retrieved from organizational ERP systems such as demographics and error counts.

The course titled "General Solid Rivet Application" was selected as the targeted technical training for this dissertation. In accordance with the research design, two achievement tests for measuring the solid rivet application competency of the participants were prepared. Additionally, a questionnaire called "The New World

Level 1 Reaction Sheet" was used for gathering information about trainee reactions upon completing the course. The questionnaire was devised by Kirkpatrick (2008).

The instruments used in this study are explained in detail in the following subsections.

3.4.1 Pre-course Achievement Test

The selected course was assessed by means of a written test prior to this study. The existing test was abandoned for two reasons: a) the test consisted of only written items and therefore it was not capable of measuring practical performance which was crucial in terms of rewritten learning outcomes b) the test has been used for a long while with the same items and hence items were exposed to the prospective course-takers. Consequently, the pre-course achievement test (see Appendix A) was created from scratch by the researcher in collaboration with the instructor of the course who is also a subject matter expert for this case. The test aims to determine the competency level of participants prior to the course.

The instructor had been teaching the course for 8 years at the time of the study. Also, he had performed solid rivet operations on a daily basis as a technician for 5 years prior to teaching the course. In addition, the instructor has an undergraduate degree from a technical education faculty in Turkey.

Clark's (2011) technical training guideline provides strategies and prescriptive suggestions for each content type described within the content-performance matrix such as fact, concept, process, principle, and procedure. During the redesign of the selected course, the content was analyzed into smaller pieces and each piece was labeled with the corresponding content type. Therefore, the researcher and the instructor were able to utilize Clark's (2011) suggestions in determining the assessment strategy and deciding the item formats. The primary objective of the selected course is to enable the participants to acquire solid rivet installation skills for different project specifications. Thereby, the content is comprised of a particular procedure and its supportive knowledge which is a typical case in technical training (Clark, 2011). In this case, Clark (2011) asserts that evaluation efforts need to focus on skill acquisition. Accordingly, it was decided that the pre-course achievement test should measure the practical performance of the solid rivet installation and it should measure the acquisition of the supportive knowledge through written items as well.

The pre-course achievement test is composed of 10 written items along with 5 performance tasks. Written items include multiple-choice, true-false, and short answer formats. Items are prepared to address the learning outcomes which were rewritten in the course of the study. Similarly, performance tasks correspond to the main steps of the solid rivet installation which is the ultimate concern of all learning objectives. The coupling between learning outcomes and test items is provided in The Treatment Matrix (see Appendix İ) section.

The pre-course achievement test scores range between 0 to 100. Points awarded for each written item and each performance task are presented in Appendix C. The participants are expected to have a minimum score of 70 in order to meet the certification requirement for the selected course. The cutoff point is imposed by specific regulations imposed by certain aerospace industry authorities.

Content Validity

The validity is of paramount concern for every data collection instrument in educational research. For an achievement test, three main types of validity can be examined such as content validity, criterion-related validity, and construct validity (Fraenkel, Wallen & Hyun, 2012). The content validity of an instrument refers to the extent to which the instrument measures what it is intended to measure. Cohen, Mainon & Morrison (2007) state that an instrument must demonstrate that it comprehensively and equitably encompasses the domain or items which it claims to cover.

In order to establish the content validity for the pre-course achievement test, Lynn's (1986) two-stage process which involves the development stage and judgment stage was followed. Table 3.9 shows the stages and steps of this process.

Table 3.9 Stages of Content Validity Determination by Lynn (1986)

Stage 1: Development	Identifying full content domain Item generation Instrument formation
Stage 2: Judgment	Judgment of content validity for items Judgment of Content Validity for Instrument

In the development stage, the domain was identified through learning outcomes, items were generated based on the outcomes to address all aspects of the domain, and then items were organized as an exam sheet for the purpose of instrument formation. Hence, the three steps of the development stage suggested by Lynn (1986) were employed. In the judgment stage, it is necessary to have the experts assess the content validity of each item and the content validity of the whole instrument (Lynn, 1986).

After the pre-course achievement test items were prepared, a panel of experts was constituted for ensuring the content validity. Lynn (1986) recommends that the panel of experts should have at least 3 members whereas the Lawshe (1975) method requires a minimum of 5 experts. The researcher managed to assemble a group of 5 senior technicians which meets the criteria.

Each expert in the panel;

- ✓ had experience in solid rivet operations for more than 10 years
- ✓ had taught the original course in the past as a part-time instructor
- ✓ had overseen inexperienced technicians for solid rivet operations
- ✓ was confirmed for being an expert on solid rivet installation by their supervisors

Furthermore, 3 out of 5 experts reportedly participated in the review of the selected course in 2018 in order to improve it. In a nutshell, all panel members were highly familiar with both the course and the subject matter with a proven track record.

After the panel of experts agrees to voluntarily contribute to the test review process, an e-mail was sent to each of them. The e-mail included a cover letter that summarizes the purpose of the study, a list of learning outcomes for the course, a sample of the exam sheet, the content validity rating form (see Appendix D), and also a demo record of the expected performance tasks. The experts were requested to conduct their reviews independently.

The content validity rating form includes Davis's (1992) approach as well as the Lawshe (1975) method in order to be able to calculate both Content Validity Index (CVI) and Content Validity Ratio (CVR) values. Table 3.10 depicts the formulas and expressions for the calculation of both measures.

Table 3.10 Calculations For Content Validity Metrics

Validity Measure	Acronym	Reference	Calculation Formula	Notation
Content Validity Ratio	CVR	(Lawshe, 1975)	$CVR = \frac{N_3}{N_E/2} - 1$	N_3 : Number of experts who rate 3 (essential) N_E : Number of all experts who rated the item
Content Validity Index	CVI	(Lynn, 1986)	$CVI = \frac{N_{3\text{-}4}}{N_E}$	$N_{3\text{-}4}$: Number of experts who rate 3 (quite relevant) or 4 (very relevant) N_E : Number of all experts who rated the item
Content Validity Ratio for Whole Instrument	S-CVR	(Lawshe, 1975)	$S\text{-}CVR = \frac{\sum_1^{N_I} I\text{-}CVR}{N_I}$	I-CVR: CVR value for the particular item N_I : Number of items in the instrument
Content Validity Index for Whole Instrument	S-CVI	(Lynn, 1986)	$S\text{-}CVI = \frac{N_1}{N_I}$	N_1 : Number of items with CVI value of 1.0 N_I : Number of items in the instrument

A review of the experts’ responses on the rating form yielded that 14 out of 15 items were judged as valid (see Appendix E for item ratings). The S-CVR value for the overall test was calculated as 0.89 while the instrument level S-CVI was found to be 0.93. On the other hand, the written item 1 obtained a CVI of 0.8 and a CVR of -0.6, and thence it failed to satisfy the minimum criteria for both measures. Providing that the panel consists of 5 experts, the Lawshe (1975) method requires an item to have a CVR value of 0.99 whereas Lynn (1986) asserts that an item is expected to have a CVI value of 1. Davis (1992) suggests that a CVI value of 0.8 can be deemed as valid though.

However, Yurdugül (2005) highlights that Davis (1992) proposes a fixed reference value which does not involve any comparison with certain statistical criteria. Accordingly, Yurdugül (2005) states that CVR values of items can be compared with the corresponding minimum values in Veneziano & Hooper's (1997) table. The table indicates a minimum CVR value of 0.99 for the case of 5 experts. Therefore, it was decided to replace the written item 1 with a new item which is called written item 11. The newly created item was also sent to the panel experts and their ratings for this single item were collected. No other revision was applied to the items of the pre-course achievement test. As a result, all items in the final version were qualified as valid with respect to both the CVI and CVR criteria. Table 3.11 summarizes the instrument-level content validity ratings before and after item revisions.

Table 3.11 Scale-Level Content Validity For Pre-Course Achievement Test

Metrics	For Original Item Pool	After Item Replacement	Acceptable Value
S-CVR	0.89	1.0	0.8 (Rutherford-Hemming, 2015)
S-CVI	0.93	1.0	0.8 (Polit & Beck, 2006)

3.4.2 Post-course Achievement Test

Prior to this study, the selected course was assessed through a single test which was abandoned after the study. For research purposes, solid river installation achievement was assessed by two tests. Post-course test and pre-course test were prepared simultaneously. All stages of test development and validation were identical for both tests since two tests are expected to be equivalent in terms of how they measure the achievement. The post-course achievement test (see Appendix B) aims to determine the competency level of participants upon completion of the selected course.

The same instructor was the subject matter expert for preparing the post-course test as he did for the pre-course test. Clark's (2011) evaluation suggestions and strategies were employed for generating the items of the post-course test which is also the case for the pre-course test. Expectedly, the post-course test is comprised of 10 written items along with 5 performance tasks. Each item was attempted to correspond with an item from the pre-course test.

The post-course achievement test scores range between 0 to 100. Points awarded for each written item and each performance task are presented in Appendix C. The participants are expected to have a minimum score of 70 in order to meet the certification requirement for the selected course. The cutoff point is imposed by specific regulations imposed by certain aerospace industry authorities.

Content Validity

The content validity establishment procedure for the post-course test was identical to the one applied for the pre-course test. Lynn's (1986) two-stage process was followed again. Table 3.9 shows the stages and steps of this process. The same assembly of 5 experts participated in the item review which produced very similar results to those of the pre-course test.

A review of the experts' responses on the rating form yielded that 14 out of 15 items were judged as valid (see Appendix F for item ratings). The S-CVR value for the overall test was calculated as 0.87 while the instrument level S-CVI was found to be 0.93. On the other hand, the written item 1 obtained a CVI of 0.8 and a CVR of -1, and thence it failed to satisfy the minimum criteria for both measures. Providing that the panel consists of 5 experts, the Lawshe (1975) method requires an item to have a CVR value of 0.99 whereas Lynn (1986) asserts that an item is expected to have a CVI value of 1. Davis (1992) suggests that a CVI value of 0.8 can be deemed as valid though.

However, Yurdugül (2005) highlights that Davis (1992) proposes a fixed reference value which does not involve any comparison with certain statistical criteria. Accordingly, Yurdugül (2005) states that CVR values of items can be compared with the corresponding minimum values in Veneziano & Hooper's (1997) table. The table indicates a minimum CVR value of 0.99 for the case of 5 experts. Therefore, it was decided to replace the written item 1 with a new item which is called written item 11. The newly created item was also sent to the panel experts and their ratings for this single item were collected. No other revision was applied to the items of the pre-course achievement test. As a result, all items in the final version were qualified as valid with respect to both the CVI and CVR criteria. Table 3.12 summarizes the instrument-level content validity ratings before and after item revisions.

Table 3.12 Scale-Level Content Validity For Post-Course Achievement Test

Metrics	For Original Item Pool	After Item Replacement	Acceptable Value
S-CVR	0.87	1.0	0.8 (Rutherford-Hemming, 2015)
S-CVI	0.93	1.0	0.8 (Polit & Beck, 2006)

3.4.3 The New World Level 1 Reaction Sheet

According to Kirkpatrick's (1959) four levels of training evaluation model, level 1 corresponds to trainee reactions. Kirkpatrick & Kirkpatrick (2016) provides an updated version of the four levels of evaluation model which they call “The New World Kirkpatrick Model”. The new model is concerned with common misinterpretations of the Kirkpatrick Model and thus does not suggest foundational alterations. According to the New World Kirkpatrick Model, the level 1 evaluation efforts should be directed at gathering information about engagement, relevance, and customer satisfaction (Kirkpatrick & Kirkpatrick, 2016). It is recommended to use rating questionnaires for level 1 which addresses three concerns of reaction level. It should be noted that Kirkpatrick & Kirkpatrick (2016) emphasizes that level 1 is an occasion for saving resources not spending them. Hence, it is important to understand that this level of evaluation is conducted for having some initial indicators in terms of considering if the program and instructor performances are acceptable. Therefore, level 1 efforts are expected to be quick, uncomplicated, and cost-efficient (Kirkpatrick & Kirkpatrick, 2016).

Consequently, a “reaction sheet” proposed by Kirkpatrick (2008) was utilized in the present study. A reaction sheet is essentially a four-point rating questionnaire. Participants are expected to rate each item using the following labels: Strongly Disagree (1), Disagree (2), Agree (3), and Strongly Agree (4). A total of 21 questionnaire items are grouped as sections such as program objectives, course materials, content relevance, facilitator knowledge, facilitator delivery, facilitator style, program evaluation, breaks, and facility. One of the items is associated with both facilitator style and facilitator delivery categories. Therefore, the reaction sheet applied to the participants (see Appendix G) included 20 items without any recurring items. But the response of item 9 is associated with the facilitator style as well as the facilitator delivery category.

It should also be noted that reaction sheets can be administered based on two different approaches. Items can be written either in a trainer-centered fashion or in a learner-centered fashion. Kirkpatrick (2008) strongly criticizes the prevalent use of trainer-centered items in reaction sheets stating that it is the learner whose perspective is attempted to be understood in the first place. Correspondingly, a learner-centered pool of items was used in the current study.

The instrument does not rely on any psychometric constructs and the sole purpose of using it was seeking for any extreme problems which are likely to be reflected on participant reactions following the course delivery.

3.5 The Treatment Conditions

Each experimental study is expected to have some form of treatment for at least one of the experimental groups (Cohen, Manion & Morrison, 2007). The treatment employed in this study is teaching a certain course after a redesign process based on Clark's (2011) technical training design guideline. On the other hand, the control group was taught the original version of the same course. The treatment is of utmost importance for experimental studies as it is assumed to be the cause of the observed effects on dependent variables.

The treatment can be summarized in three stages such as preliminary work, redesign of the course, and the delivery of the course.

3.5.1 Preliminary Work

Before proceeding to the course redesign phase, it was necessary to ensure that the subject matter expert has a firm understanding of Clark's (2011) technical training design guideline so that he can provide consultancy and active participation throughout the treatment process. Accordingly, the subject matter expert was provided with a 2-day (6 hours long) training on Clark's (2011) instructional design guideline. The training was instructed by the researcher. Clark (2011) provides exercises for testing the reader’s understanding of her approach. The subject matter expert was requested to respond to the exercise items upon completion of the brief training sessions. Table 3.13 shows the performance of the subject matter expert on technical training design guideline exercises.

Table 3.13 Subject Matter Expert’s Performance On Exercises

Exercise Subject	Item Count	Correct Response	Incorrect Response
Concepts	5	5	0
Facts vs concepts	6	5	1
Processes	6	6	0
Procedures vs principles	5	3	2

The subject matter expert responded 86.3% of the exercise items correctly. Nonetheless, the topic related to the distinction of procedures and principles was revisited in an extra training session after the exercises. Afterwards, the subject matter expert expressed his confidence in interpreting the design guideline and it was decided to proceed to the redesign stage of the treatment.

3.5.2 The Original Course

The structure and instructional design history of the original version of the course will be explained before providing the interventions applied within the scope of the treatment.

Turkish Aerospace Academy offers hundreds of courses for its employees and 300 of them can be categorized as technical training with respect to Clark's (2011) definition. In order to determine the course to focus in the present study, the catalog of technical training courses was meticulously reviewed. It was found out that certain courses were designed by people with undergraduate degrees from education faculties and they adopted the ADDIE model whereas others were designed by people with no background in education without complying with any kind of instructional design models.

Consequently, it was decided to select a course among those designed with the ADDIE model. The decision was based upon the fact that redesigning a course that has never undergone the instructional design process would make the treatment more about the effect of instructional design in general. However, this study aims at investigating the effect of a specific instructional design approach, namely, Clark's (2011) technical training development guideline.

Course Selection Criteria

The primary concern for selecting the course was the feasibility of collecting a quantitative indicator of the job performance for the participants before and after the course, which is necessary for the research design. A secondary criterion was finding a course with a large target audience. Thereby, not only finding participants for the study would be less challenging but also the impact of the findings from the study would affect more employees. The third criterion in selecting the course was whether it is possible to reach out to a subject matter expert and an instructor who will be available for a comprehensive collaboration throughout the study. Lastly, the target course was required to be designed by following an instructional design process instead of being the result of an unstructured effort.

After a careful examination of the catalog concerning the criteria explained above, the course to redesign in the study was determined. Table 3.14 presents the general catalog information for the selected course.

Table 3.14 General Catalog Information For The Selected Course

Attribute	Information
Title	General Solid Rivet Application
Duration	16 Hours (12 Hours of Lecture, 4 Hours of Application)
Category	Structural Operations
Target Audience	Technicians working on aircraft manufacturing and assembly operations
Facility	Classroom (lecture), training workshop (application)
Renewal Period	5 Years
Assessment	Participants are required to score 70 out of 100 on the test
Language	Turkish

Significance of The Course

General Solid Rivet Application course is an essential instructional requirement for the majority of all technicians in the company since it covers one of the most fundamental operations in aerospace manufacturing: rivet installation. Thereby, the course has a large-scale impact on operational quality.

Mechanical devices that hold two or more parts in definite positions with respect to each other are called “fasteners”. Fasteners permit the transfer of physical loads between parts and thus they provide flexibility in aerodynamics design. Accordingly, they are an integral part of aircraft assembly processes. As a case in point, the number of fasteners used in building Boeing airliners ranges from 440.000 to 2.700.000 (Lee & Anupindi, 2009) to put it into perspective, an average car has about 3.500 fasteners installed on it (Kruszelnicki, 2020). The use of fasteners in the aerospace industry is far more frequent compared to any other industry and the consequences of errors on fastener installation are fatal. Therefore, technicians are expected to perform installation operations fluently and in an errorless manner to be competitive.

A solid rivet (illustrated in Figure 3.1) is a specific type of fastener which is commonly used in many different conditions. Holes are prepared beforehand and solid rivets are inserted into holes in a way that satisfies certain specifications depending on the project or customer requirements. This is called “installation”.

Figure 3.1. Solid Rivets With Universal Head

General Solid Rivet Application course is expected to enable technicians to conduct end-to-end installation operations. Performance of technicians on rivet installation directly affects production rate, rework and repair costs, airworthiness of the product, customer satisfaction, and future contracts for the organization. For this reason, the General Solid Rivet Application course is one of the initial courses for new employees and experienced employees are also required to take the course periodically in order to ensure that their knowledge and skills are refreshed.

Instructional Design of the Course

The course was originally designed by a technical instructor who has an undergraduate degree from a technical education faculty in Turkey. He also has certificates related to training design obtained from Boeing and Airbus. The instructor provided detailed information about the design process that took place in 2018. Before 2018, there were different courses about solid rivet applications each of which addressing particular project requirements and specifications. The instructor stated that this course was created to replace project-specific courses and eliminate redundancy.

General Solid Rivet Application course was prepared in order to fulfill the training need described in a classified quality document that regulates the training programs of the employees. The document only expresses the need for a training course dedicated to teach solid rivet installation involving both theoretical and practical components with a duration of minimum 16 hours. However, specific objectives, instructional methods, or materials are not dictated by the document.

The technical instructor reports that he decided to design the course according to the ADDIE model because this model is the only instructional design model on which he felt confident about implementation. First of all, the technical instructor who has 13 years of experience in rivet operations had consulted with other senior employees to determine the outline and content of the course. He had reportedly visited three different senior technicians who were actively working on the same operation at the moment of their meeting.

This stage of visits had involved both the analysis and design steps of the ADDIE model. Senior technicians had helped the technical instructor to determine the scope of the course and also they had collectively penned the learning outcomes which they call “target behaviors”. The technical instructor highlights that “the target behaviors are decided upon the expectations of the actual practitioners” and thus “the trainees can easily relate to the course”.

According to the technical instructor, he had followed the lead of the senior technicians in determining the so-called “target behaviors” whereas he had led the design-related discussions. He elaborates that “the target behaviors were how the operators characterize the nature of the operation but I had to step forward for designing because I was the only one with an educational background”. Subsequently, he had created a course outline that is centered around but not limited to the “target behaviors”. He explains that he had wanted to present some background and context for the rivet operations and therefore he had included topics like different standards in industry or generalizability of the course. He also reports that he had tried to apply some sequencing approaches. The content was ordered in a chronological manner with respect to the steps of a rivet installation operation. He also underlines that the content had been sequenced in a way that is from simple to complex. As a result, the main topics of the course were determined and ordered as shown in Table 3.15.

Table 3.15 Main Topics Of The Original Course

Topics	Subtopics
Solid rivet application	General description
	Specifications
	Standards
Introduction to rivets	Rivet types
	Rivet definition protocol
	Rivets on technical drawings
Conditions of use	Heat work
Rivet installation procedure	Spacing and distances
	Hole diameters
	Rivet length
	Equipment and tools
	Hole Preparation
	Countersinking
	Critical warnings
Quality Control	Audit criteria
	Trimming
	Removal of non-conforming installations

3.5.3 Redesign Of The Course

The course was redesigned in accordance with Clark's (2011) technical training design guideline. The redesign of the course involved interventions in four dimensions which are learning outcomes, the content, instructional methods, and the delivery media to some extent. The guideline is formulated so that it provides general knowledge, suggestions, warnings, strategies, and examples from business scenarios for each of four dimensions depending on the content type.

Learning Outcomes

First and foremost, learning outcomes were written for the selected course. The original course had objectives which were named “target behaviors” (See Table 3.14) prior to the treatment. Clark (2011) has concrete prescriptions in terms of writing learning outcomes for each content type. For instance, she states that there is no need for writing learning outcomes for facts. Because the facts can only be performed at the “Remember” level of the content-performance matrix and articulation of factual information does not guarantee that it is going to be used properly in the course of actual performance. The complete list of Clark's (2011) learning outcome writing suggestions can be found in the Content-Performance Matrix Interpretation For The Study (see Appendix H) under the “Learning Outcomes” column.

Table 3.16 presents the learning outcomes written by following Clark's (2011) suggestions.

Table 3.16 Learning Outcomes Written Following Clark's (2011) Suggestions

Content Type	Learning Outcome
Principle	Decide whether it is appropriate to use solid rivet for a given condition
Concept	Distinguish between different types of solid rivets
Process	Interpret the rivet code strings correctly
Concept	Identify the material of a given solid rivet based on visual cues
Procedure	Determine the hole diameter for any given solid rivet
Procedure	Install the solid rivet by satisfying exceeding length and gap criteria
Procedure	Audit an installed solid rivet to understand whether it is non-conforming for a given specification
Procedure	Remove a non-conforming solid rivet without causing cracks or scratches to the structural part

The Content

As the first step of content treatment, existing subtopics were broken down into fundamental pieces of content. Subsequently, each fundamental piece was classified through the content-performance matrix (see Figure 2.6). For each content type, Clark (2011) provides straightforward instructions and concrete examples for determining what kind of information display to be used and its general attributes. She presents a clear rationale for each decision as well. Instructional material design and media issues are not primary concerns for this study. Therefore, issues of multimedia or message design are not included in the treatment. The treatment is directed at selecting a form of information display suggested by Clark's (2011) guideline and replicating the examples as they are presented. For example, the guideline provides sample action tables and elaborates the most critical components in these tables. Accordingly, an action table with the same highlighted components was created in the scope of the treatment when it was recommended for a particular content type. Existing displays and materials were preserved when they comply with the suggestions of the guideline as well. The complete list of Clark's (2011) information display suggestions can be found in the Content-Performance Matrix Interpretation For The Study (see Appendix H) under the “Information Displays” column.

Instructional Methods

One of the most influential dimensions of the treatment was the alteration of the instructional methods employed in the delivery of the selected course. Clark (2011) proposes different instructional method combinations for different content types. The guideline also recommends using certain information display formats as part of certain instructional methods. For instance, the guideline suggests using visuals of examples and non-examples with callout labels under the information display advice. Then, it is recommended to have the participants perform an identification task as a classroom exercise between the example and the non-example of the concept. Hence, instructional methods are not proposed directly. Instead, they are presented within scenarios that incorporate other types of recommendations.

It should be noted that Clark's (2011) approach results in diversification of instructional methods as well as increased participant engagement. Because overall suggestions focus on the acquisition of the target skill which requires active learner participation. Additionally, a monotonous instructional method use is avoided by altering the method for each temporary foci of the content. In this way, a dynamic learning environment can be achieved by following the guideline.

The complete list of Clark's (2011) instructional methods suggestions can be reviewed by examining the “Information Displays” column and “Practice Exercises” column together in the Content-Performance Matrix Interpretation For The Study (see Appendix H).

Delivery Media

Clark (2011) specifies certain mediums for delivery of the content depending on the content type. The delivery medium for each fundamental content was decided concerning the suggestions. Since the course was required to be a classroom course as per the quality documents, the use of electronic mediums before and after the course was avoided. Hence, suggestions regarding the e-learning implementation were excluded from the treatment. The treatment only focused on the instructor-led classroom scenario.

Consequently, delivery media was not altered to a greater degree as a result of the guideline implementation. This is also in line with the purpose of the present study. This study aims to investigate the effect of a particular technical training design approach. Therefore, the medium of the instruction is not required to be manipulated.

The complete list of Clark's (2011) delivery media suggestions can be found in the Content-Performance Matrix Interpretation For The Study (see Appendix H) under the “Delivery Media” column.

Evaluation

Clark (2011) introduces evaluation suggestions that vary in terms of style and specificity. The main premise that underlies the suggestions is that technical training is about acquiring certain job skills as well as the supportive knowledge that is essential for the performance of the skills. Correspondingly, the evaluation suggestions focus on assessing the procedural task performance and include the supportive content with respect to its essentiality for the performance. For instance, Clark (2011) strongly highlights that certain content, like the knowledge of relevant processes, might not be included in the assessment even though it was taught in the course. Because its relation to the execution of the target skill is secondary. Thereby, the technical training design guideline aims to refine the assessment and concentrate it on what is likely to be transferred to the actual job performance.

Table 3.17 A Sample From Clark's (2011) evaluation suggestions

Content Type	Exemplary Suggestion
Fact	Do not address the repeating of factual information. Instead, require authentic job tasks that require the use of factual information.
Concept	Have the trainee perform identification of examples. If performance-based identification is not possible, use multiple-choice items to examine if the trainee can identify the example of the concept.
Process	Have the trainee solve a problem based on process knowledge. The problem can be a fictional one and the solution can be provided verbally or in a written format.
Principle	Present a job-realistic scenario that requires the application of principles or guidelines. Use a checklist that includes expected principles.
Procedure	Have the trainee perform the job task with no help. Use a yes-no checklist that examines whether a specific performance occurred at each step.

The complete list of Clark's (2011) technical training evaluation suggestions can be found in the Content-Performance Matrix Interpretation For The Study (see Appendix H) under the “Evaluation” column.

3.5.4 Delivery Of The Course

The researcher had two versions of the same course upon completing the redesign process. Both versions of the courses were administered and taught under identical conditions with the exception of their respective target audiences.

The same instructor led the 6 sessions of the General Solid Rivet Application course each of which took 16 hours. 16 hours were spent for two consecutive days for each session. Initial 12 hours on the first day of the sessions were taught in a conventional classroom whereas the last 4 hours were completed in a training workshop on the second day of the sessions. Duration and the split of the hours were the same across all 6 occasions. The first day of the course sessions focused on supportive knowledge and theoretical foundations of the target skill. The second day of the course sessions involved hands-on practice and feedback for performance.

The same facilities, materials, and equipment were used across all 6 occasions. Sessions spanned 4 consecutive weeks and they all took place in the same season of the year. Each session was completed with 20 participants without any nonattendance.

Throughout the delivery, 3 groups of participants were exposed to the original version of the course whereas the other 3 groups were exposed to the redesigned version of the course. The instructor conducted the whole process and the researcher did not physically participate in any sessions until the participants completed the post-course test and reaction questionnaire. After all the treatment conditions were finished, the researcher visited the workshops only to thank the participants. Therefore, all 6 sessions were conducted under authentic conditions without any difference from the other sessions that took place simultaneously at the Turkish Aerospace Academy building.

Firstly, the instructor taught the original course on 3 consecutive occasions since it requires the usual behavior of the instructor which he has been following for years. Afterward, the instructor used the weekend for preparation and taught two groups for rehearsal on how to teach the redesigned course. These two groups were not part of the present study. The rehearsal mainly focused on the timing and sequence of new instructional methods and getting used to new information displays. After feeling confident about teaching the redesigned course, instructor led 3 consecutive occasions for the treatment group.

3.5.5 Summary Of The Treatment

The treatment of the present study is centered around redesigning a technical training course and delivery of both the new and original versions of the courses. Prior to the redesign, the instructor was trained for understanding and applying Clark's (2011) technical training evaluation. The course was redesigned based on Clark's (2011) guideline which involves classifying the content and then following particular suggestions for each type of content. Redesign work included writing learning outcomes, classifying content and creating information displays, utilizing certain instructional methods for certain cases, using particular delivery media for specific types of content, and lastly following the suggestions of the guideline to measure the outcomes.

The treatment was shaped by the researcher's interpretation of the content-performance matrix (see Appendix H). This specific matrix was used as the reference for making instructional decisions. All the decisions and changes made in the course of treatment were presented in The Treatment Matrix (see Appendix İ).

3.6 Data Collection Procedures

General procedures followed in the course of this study are illustrated in Figure 3.2 below. This subsection will elaborate on data collection procedures in particular.

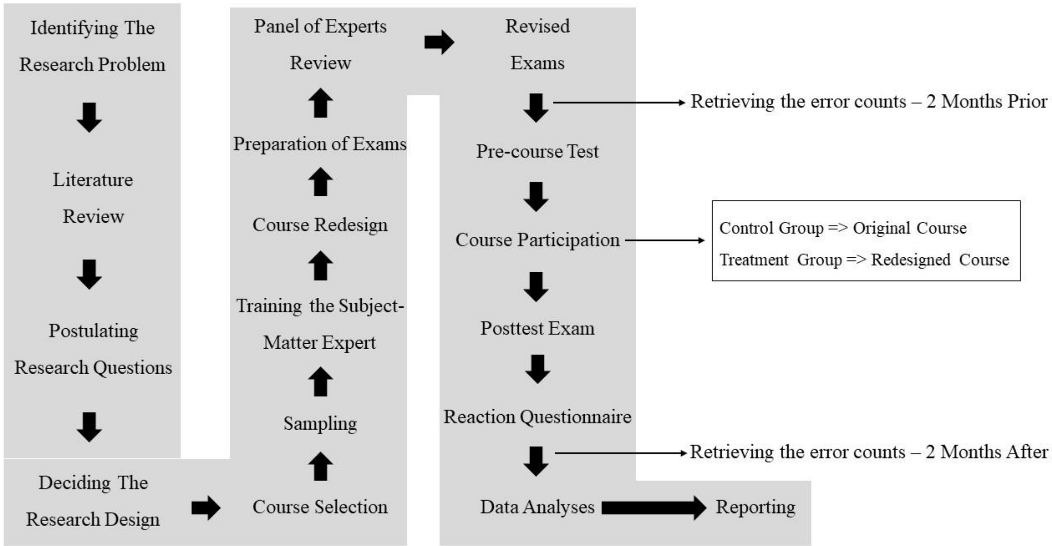

Figure 3.2. General Procedures Of This Study

Pre-Course Error Counts

The first step of the data collection was retrieving the error counts of the participants 2 months before they take the course. As per the organizational practices, it was customary to review error counts on a monthly basis. Therefore, the metrics from May 2020 and June 2020 were retrieved. However, minor adjustments were made because the very first participant group took the course on the last two days of June 2020. Accordingly, for this specific group of participants, the last two workdays from April 2020 were included in order to complete the metric time period to two months.

The error counts refer to recorded and documented non-conformities in operations. All steps of the operations conducted by the technicians are subject to strict inspection processes through various methods. When the inspectors detect conditions on a part or process which does not meet certain criteria they issue a non-conformity report or NCR. The NCRs are created, stored, and monitored digitally by means of an ERP software. The inspector inputs all the necessary parameters to the software and then provides the responsible technician and/or his supervisor with feedback for corrective action. Quality inspections are a routine part of everyday work and they are conducted on a consistent periodical basis. For technicians, error counts are used as key performance indicators or KPIs within the organization. According to Bishop (2018), KPIs are quantifiable or qualitative measures that allow businesses to assess their success in accomplishing strategic and operational objectives. Manalu (2010) highlights that organizational performance records are credible data sources for linking training interventions to organizational objectives.

All NCRs include a parameter that specifies the root cause of the detected error. For the purposes of this study, both the panel of experts reviewing the exams and quality supervisors were consulted to determine the relevant root cause codes that can be related to solid rivet application skills. Accordingly, only the NCRs with certain root cause codes were obtained as part of this study. Since the NCR management involves classified information, it is not possible to report further details. However, it can be summarized that the researcher retrieved the error counts for participants of the study which are reportedly associated with the learning outcomes of the selected course.

Informed Consent Form

When the participants of each course session gathered in the classroom, they were first given the informed consent form (see Appendix J). Although they were already informed of the fact that they are invited to be part of a research study via e-mail, it was reminded that they can prefer to leave if they want to. Fortunately, none of the participants left. After ensuring that everyone intends to proceed, they were asked to sign the informed consent form if they accept the terms.

Demographics

Demographic information such as work experience, educational background, previous training records, and age were retrieved from organizational ERP software based on the permission of the participants through the informed consent form and the permission of the organizational administration.

Pre-course Achievement Test

When the participants of each course session gathered in the classroom, they were given the pre-course achievement exam sheets. They were required to complete the exam in 20 minutes. Then, the instructor collected the exam sheets and then invited all participants to the application workshop for the performance examination. Participants waited outside of the workshop until they are called in two-by-two. Each participant was given 5 minutes to complete the performance tasks. Two exam takers were placed on adjacent workbenches. Each workbench is separated from the other with a paravane. Hence, participants were not able to observe each other's performance. However, the instructor is positioned in the middle of adjacent workbenches so that he can clearly observe both performances and fill the checklist for both exam takers. The instructor assessed one test-taker at a time. No simultaneous performances were allowed to avoid any bias from the instructor. The performance task instructions of the exam sheet were fixed on the workbench paravane and it was accessible throughout the performance. Participants were not permitted to ask any questions in the course of both written and practical examinations. After the 5 minute time runs out, pairs of participants were taken to the cafeteria to wait for the rest of the group with the companionship of another technical instructor. Hence, it was aimed to avoid interaction between the participants who complete the exam and those who keep waiting for their turn. The whole examination process lasted for approximately one hour.

Eventually, the data was collected in the form of written exam sheets (see Appendix A) and a performance evaluation checklist (see Appendix C).

Post-course Achievement Test

Upon completing the pre-course achievement test, the course started after a brief 10 minutes break. After the 16-hour long course was completed in the application workshop on the second day of the session, post-course achievement data were collected following the very same approached used for the pre-course data.

All participants were invited back to the classroom for the written exam utilizing the post-course achievement exam sheet. Afterward, they were again gathered outside the workshop, and then they were invited in as pairs. The rest of the procedure for the performance exam was identical to the one applied for the pre-course test. Eventually, the data was collected in the form of written exam sheets (see Appendix B) and a performance evaluation checklist (see Appendix C).

The New World Level 1 Reaction Sheet

When a pair of participants complete their performance exams in the workshop, they were taken to the cafeteria with the companionship of a technical instructor. When they arrive in the cafeteria, they were given a web link to access through their cell phones. The link displays the New World Level 1 Reaction Sheet. All participants provided their responses through the online questionnaire form. Turkish Aerospace Academy uses the same online questionnaire service for conducting post-course participant surveys. Therefore, the same method was employed within the scope of the study. The online form was created and applied on a subscription-based web service called SurveyMonkey. Eventually, the reaction sheet data was exported from the system in the form of an SPSS file.

Post-Course Error Counts

The last step of the data collection was retrieving the error counts of the participants 2 months after they took the course. As per the organizational practices, it was customary to review error counts on a monthly basis. Therefore, the metrics from August 2020 and September 2020 were retrieved. In an identical way to pre-course error counts, only the NCRs with specific root causes were obtained. Root causes that are associated with the learning outcomes of the selected course were used.

Table 3.18 below presents the timeline of the data collection.

Table 3.18 Data Collection Timeline

Data Collection Step	Corresponding Time Period
Pre-course error counts retrieved	29-30th April 2020 May 2020 June 2020
Course delivery on 6 occasions to collect data through the following instruments: Pre-course achievement tests Post-course achievement tests The New World Level 1 Reaction Sheets *(all 3 instruments used once for each occasion)*	29-30th June 2020 *(Occasion 1)* 1-2nd July 2020 *(Occasion 2)* 6-7th July 2020 *(Occasion 3)* 16-17th July 2020 *(Occasion 4)* 21-22nd July 2020 *(Occasion 5)* 23-24th July 2020 *(Occasion 6)*
Post-course error counts retrieved	August 2020 September 2020

3.7 Data Analysis

The data were analyzed by means of descriptive and inferential statistics. The data analysis procedures were conducted by using IBM SPSS 26 program. Descriptive statistics were used to address the third research question concerning the participant reactions after the course. On the other hand, the first and second research questions were investigated through inferential statistics methods.

The New World Level 1 Reaction Sheet is not a scale that measures certain psychological constructs but rather it can be considered as a closed-ended interview. Therefore, it is not reasonable to analyze the data from the reaction sheet for variance or mean differences. The reaction sheet was expected to provide indicators of severe problems. Accordingly, the experimental groups were not compared in terms of reaction sheet scores. Reaction sheet scores were presented in terms of descriptive statistics for main categories and overall responses.

The first research question concerns revealing whether the redesigned course increases post-course achievement scores while holding the pre-course achievement scores constant. Correspondingly, a one-way ANCOVA analysis was carried out to address the research question. The level of significance for the analysis was determined as .05. The post-course achievement score was the dependent variable of the analysis whereas the experimental group was employed as the independent variable. Additionally, the pre-course achievement score was included in the model as the covariate. Thus, the analysis examined whether there is a significant mean difference between the treatment group and the control group in terms of post-course achievement after adjusting for the pre-course achievement levels. Prior to the analysis, independent observations, normality, linearity, homogeneity of the regression, and homogeneity of the variances assumptions were controlled.

The second research question investigates if there is a significant difference across experimental groups in terms of post-course error counts when the pre-course error counts are held constant. Correspondingly, a one-way ANCOVA analysis was conducted to address the research question. The level of significance for the analysis was determined as .05. The post-course error count was the dependent variable of the analysis whereas the experimental group was employed as the independent variable. Additionally, the pre-course error count was included in the model as the covariate. Thus, the analysis examined whether there is a significant mean difference between the treatment group and the control group in terms of post-course error counts after adjusting for the pre-course error levels. Prior to the analysis, independent observations, normality, linearity, homogeneity of the regression, and homogeneity of the variances assumptions were controlled.

3.8 Validity And Reliability

Both reliability and validity issues are paramount concerns in drawing conclusions from research findings. On that account, each step of the research procedure was executed by addressing reliability and validity issues.

3.8.1 Validity

Fraenkel, Wallen & Hyun (2012) state that the validity is the measure of the extent to which an instrument or research serve their intended purposes. In this study, two achievement tests were prepared and an experimental research design was followed. Thereby, content validity and criterion validity issues are addressed for both tests whereas internal validity and external validity issues are concerned for the overall research.

Content Validity

Content validity establishments for achievement tests are explained in the 3.4 Data Collection Instruments section (see subsection 3.4.1 and 3.4.2). In the conclusion, content validity evidence was provided for both instruments.

Criterion Validity

Another method for forming validity evidence is called “criterion validity”. The criterion validity relies on utilizing another instrument that measures the same variable for demonstrating that the original instrument produces valid measurements (Fraenkel, Wallen & Hyun, 2012). The present study focuses on the redesign of a technical training course that aims to enable the participants to acquire solid rivet installation skills. The achievement tests employed in this study purport to measure participants’ knowledge and skill levels on solid rivet installation. The present study also collects the data regarding error counts associated with actual solid rivet installation operations. Thence, it can be inferred that both the achievement test scores and error counts are indicators for the solid rivet installation skills of the participants. Therefore, it was decided that error counts can be used as a reference indicator for the characteristic that is expected to be measured through achievement tests. Namely, the pre-course error counts are used as a criterion for pre-course achievement test scores while the post-course error counts are used as a criterion for post-course achievement test scores. Since there are two months time intervals between error count recordings and achievement tests, this kind of validity evidence can be considered as predictive validity (Fraenkel, Wallen & Hyun, 2012).

A common method of examining criterion validity is to investigate how well the original instrument correlates with some other known measures of the characteristic that is in question (Cohen, Manion & Morrison, 2007, p. 46). By following this approach, bivariate correlations were calculated.

It was found out that the pre-course achievement test scores were significantly correlated with pre-course error counts, $r = -.61$ ($p < .05$) whereas the post-course achievement test scores were significantly correlated with post-course error counts, $r = -.71$ ($p < .05$).

Negative correlations are due to the fact that successful execution of the target skill translates into achievement scores as higher values, in contrast, it is reflected on the error counts as lower values. A skillful technician is expected to conduct fewer errors and obtain higher grades from the exam. In addition, Green & Salkind (2005) report that correlation coefficients greater than .50 can be considered as large correlations in behavioral sciences. Hence, it can be concluded both of the calculations yielded large correlations between respective variables. Table 3.19 shows the bivariate correlations between the variables.

Table 3.19 Correlations For Criterion Validity

	1	2	3	4
1.Pre-course achievement score	1.00	$-.61^{*}$		
2.Pre-course error count	$-.61^{*}$	1.00		
3.Post-course achievement score			1.00	$-.71^{*}$
4.Post-course error count			$-.71^{*}$	

* p < .05

The large correlations between achievement scores and error counts can be interpreted so as the exams prepared in the course of study are capable of predicting participants' solid rivet installation error counts to some extent.

Internal Validity

According to Creswell (2012), internal validity refers to the validity of inferences derived regarding the cause-and-effect relationships between independent and dependent variables. A number of situations can pose threats to internal validity and therefore they should be controlled in the course of research studies (Fraenkel, Wallen & Hyun, 2012). The measures taken to address subject characteristics, mortality, location, testing, and attitude of subjects are explained below.

In order to avoid selection bias, participants were selected from the accessible population by assigning random indexes. Thus, it was aimed to form a sample that is as much as representative of the accessible population characteristics. Although the participants were selected randomly, the participant group was examined in terms of educational background, relevant work experience, and prior exposure to the selected course. The three characteristics were reportedly important for the performance of solid rivet installation operations. It was assured that those characteristics are distributed in a balanced way across the experimental groups and it was also checked that the distribution of these properties within the participants is similar to their distribution in the accessible population. The demographics data from the organizational ERP software was used to evaluate the similarities. An uncommon case for the subject characteristics of the population was the gender distribution. Women accounted for only 1.1% of the target population. The percentage of female technicians was even lower for the accessible population. As a result, the randomly selected participant group turned out to be uniform in terms of gender as it consists of male technicians. Although it is an uncommon case, the participant group was not altered since it represents the gender bias in the population.

One of the concerns for determining the target course from a catalog of 300 technical trainings was having a frequently taught course with a large prospective audience. This helped for taking precautions against mortality. It was planned to invite more technicians to the course in case of losing a considerable amount of participants. The selected course has been implemented on a weekly basis and hence it was possible to conduct new waves of data collection in short term. Fortunately, all the participants from the original random selection completed the course and exams. Therefore, there was no need to utilize backup plans for addressing the mortality threat.

All occasions of the data collection took place in three locations: a classroom, an application workshop, and a cafeteria (through cell phone). The locations, their inner conditions, and their sequences were held constant for all six occasions. Thereby, the researcher aimed to avoid any unintentional effects that may stem from environmental factors.

Since pre-tests and post-tests were utilized, a testing threat required some consideration. Test performance of the subjects might be affected when they took a similar test beforehand (Fraenkel, Wallen & Hyun, 2012). This threat was addressed in the statistical analyses. Pre-course achievement test results were used as covariates in order to remove their possible effects on post-course achievement test results. Moreover, the inclusion of the control group in the study was another factor that is expected to minimize the testing threat.

Subjects' attitude towards the research study or the researcher might affect their performance within the scope of the study (Fraenkel, Wallen & Hyun, 2012). In order to minimize this bias, the researcher was not present during the course sessions which was the usual situation for regular technical training sessions. Only the instructor was present and he led all the process. The instructor was a familiar character for the participants with whom they occasionally meet in different technical courses. Duration of the course, frequency of breaks, and rules within the facility were not altered for the study. The researcher attempted to keep the course sessions authentic as much as possible. One important exception for that is the signing of informed consent forms at the beginning of a two-day course session.

In the conclusion, the researcher utilized all the control at his disposal to minimize the threats to internal validity in the course of the study.

External Validity

Generalizability is arguably the ultimate concern of scientific research. The external validity refers to the degree to which findings of a particular study can be generalized study (Fraenkel, Wallen & Hyun, 2012). The present study is carried out with the participation of TAI technicians who work on the manufacturing or assembly of aerostructures. Therefore, the results of this study can be applied to the entire group of TAI technicians who work in the same operations. Additionally, results can be directly generalized to TAI technicians who do not work with solid rivets considering that they have a plethora of common characteristics with the participants of the study. It should also be noted that the findings of the present study can also be generalized to other aerospace/defense industry technicians or industrial workers by taking contextual similarities and common employee characteristics into account.

3.8.2 Reliability

The reliability of an instrument can be expressed in terms of how consistent results it can produce (Field & Hole, 2002). Accordingly, both the pre-course achievement test and post-course achievement test were expected to be consistent across different administrations of the instruments. Cronbach's alpha has been the most widely practiced method for investigating reliability through internal consistency. Correspondingly, alpha values were calculated for both achievement tests.

It was observed that Cronbach's alpha value for the pre-course achievement test was .81 whereas the alpha value was .78 for the post-course achievement test. According to Cohen, Manion & Morrison (2007), an alpha coefficient between 0.80 and 0.90 can be considered highly reliable whereas an alpha value between 0.70 and 0.80 can be accepted as reliable (p. 506). Hence, it was concluded that both pre-course achievement test and post-course achievement test have sufficient internal consistency to produce reliable results.

3.9 Delimitations And Limitations

There is a number of delimitations and limitations of the present study. A major delimitation of the study is that participants of this study are TAI technicians working with solid rivets. Therefore, the generalizability of the findings is higher for target populations who have similar characteristics with TAI technicians and for contexts that resemble the environmental properties of the current study. Another delimitation is that the current study focused on technical training. Training activities with non-technical content were out of concern. Furthermore, operational error counts are used as an indicator for transfer to job performance. Error counts resemble the most important aspect of the operational requirements which is precision. However, there is another indicator for successful performance in solid rivet installations which is speed. Providing that a typical aircraft is assembled with hundreds of thousands of fasteners, technicians are expected to install a solid rivet as fast as possible. The current study only examined the precision aspect of job performance due to feasibility issues. The last but important delimitation was the fact that this dissertation concentrated on the effect of instructional design, instructional methods, and evaluation. Issues regarding the multimedia design, the effect of the media, and personal variables such as motivation or personality traits were not addressed.

In addition to delimitations which were intentional, there were several limitations as well. First of all, the participants of the study consisted of only males. Hence, findings from this study must be interpreted with caution in terms of applying for female industrial workers. Secondly, there were confidentiality issues regarding the course content, participant information, error counts information, and organizational details because TAI is an aerospace company that is regulated by strict private and government units. Therefore, particular information or visuals could not be included in the final text. Lastly, supervisor interviews could not be completed and reported although they were planned. It was intended to conduct interviews with the supervisors of the participants after a reasonable time period upon completion of the course sessions. These interviews would be likely to provide information about behavioral changes of participants after the course in accordance with level 3 evaluation practices of Kirkpatrick's (1959) Model. However, it was not possible to carry out the interviews due to several reasons such as the extreme workload of the supervisors, the reluctance of the supervisors, the need for extra time to obtain a new level of organizational permissions, etc. Nonetheless, the present study attempted to link level 2 (learning through tests) to level 4 (organizational results through error counts) to compensate for the lack of level 3.

There is another issue to discuss which has the potential to impose limitations on the study. Globally experienced COVID-19 outbreak altered various aspects of daily life including workplaces. The data collection processes and interventions of the experimental treatment for this study took place at a time when the outbreak was still widely effective. This study did not address the question of how participants might have been affected by the consequences of the global outbreak in terms of their cognitive performances or physiological states. Hence, it should be noted that the ecological generalizability of the study might have been reduced by the unknown effects of the extraordinary conditions caused by the global outbreak.

CHAPTER 4

RESULTS

This chapter of the dissertation presents the findings of the study that includes descriptive statistics to make sense of the data as well as the results of inferential statistics methods. Accordingly, descriptive statistics, examination of relevant assumptions, the output of the statistical analyses, and interpretation of the results are provided.

4.1 Results On Achievement Test Scores

This section of the dissertation reports on the findings from the analysis of achievement test scores. The first research question was addressed through inferential statistics methods as explained below.

4.1.1 Determining The Analysis Method

Kirkpatrick's (1959) four levels of training evaluation model suggests that the learning of the participants must be examined in order to reveal whether the training can impart the content successfully. In line with that, the first research question of the current study is determined as: “Does the redesigned course increase post-test achievement scores after adjusting for pre-test achievement scores?” To answer the question, a one-way ANCOVA analysis was carried out.

In experimental studies, there might be certain variables that confound the results and their effect on the dependent variable must be eliminated. Upon identifying a possible confound factor, it can be used as a covariate within ANCOVA (Field, 2009). It was considered that participants’ knowledge and skill levels prior to the treatment can affect their performance in a post-course test. Accordingly, the pre-course achievement test score was a candidate for a good covariate. Before proceeding to the ANCOVA analysis, the pre-course achievement test mean scores of the experimental groups were compared through an independent samples t-test. In this way, it was checked if there is a significant mean difference across groups in terms of the possible covariate.

The independent samples t-test analysis showed that the control group had a higher mean score in the pre-course achievement test (M = 54.67, SD = 11.19) than the treatment group (M = 49.08, SD = 12.33). This difference was significant $t(118)$ = 2.60, p: .01 < .05 and it did represent a medium effect size d = .48. as presented in Table 4.1.

Table 4.1 Independent Samples t-test Results For Pre-Course Achievement Test

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Mean difference between control and treatment groups	Equal variances assumed	1.40	.24	2.60	118	.01

Providing that experimental groups had significantly different mean scores in the pre-course test, the variance coming from the pre-course test scores should be removed from the variance in post-course test scores in order to eliminate the confounding effect. Correspondingly, Green & Salkind (2005) suggest that one-way ANCOVA is an appropriate analysis for studies with a pre-test as well as the random assignment of subjects to levels of the independent variable which is the case for the present study. Table 4.2 presents the variables included in the ANCOVA and their descriptions.

Table 4.2 List Of Variables And Descriptions For ANCOVA: Post-course Test

Variable name	Description of the variable
Group	Experimental group (1: control group, 2: treatment group)
Posttest score	The score obtained from the post-course achievement test
Pretest score	The score obtained from the pre-course achievement test

4.1.2 Checking The Underlying Assumptions

After deciding the covariate, underlying assumptions of the ANCOVA were checked.

a) Normality

It is assumed that "the population distribution on the dependent variable is to be normally distributed for any specific value of the covariate within each cell defined by independent variables" (Green & Salkind, 2005).

First of all, the Kolmogorov-Smirnov test indicated that posttest scores follow a normal distribution both for the control group, $D(60) = 0.11$, p: .07 > .05 and the treatment group, $D(60) = 0.01$, p: .20 > 0.05. Also, the Shapiro-Wilk's test showed that posttest scores are normally distributed for both the control group, $W(60) = 0.97$, p: 0.12 > .05 as well as the treatment group, $W(60) = 0.97$, p: 0.24 > .05.

Additionally, z-scores are calculated for skewness and kurtosis values of the posttest scores. It was found out that the z-value of skewness for the control group is 0.08, the z-value of skewness for the treatment group is 0.03, the z-value of kurtosis for the control group is -0.80, and the z-value of kurtosis for the treatment group is -0.60. All four z-values fall between the acceptable range of -1.96 and +1.96 (Field, 2009) as shown in Table 4.3 below.

Table 4.3 Skewness And Kurtosis Z-Scores For Posttest Scores

Experimental Group	Skewness	Kurtosis	Acceptable Range
Control	0.08	-0.80	Between -1.96 and +1.96
Treatment	0.03	-0.60	Between -1.96 and +1.96

The normality assumption was also tested through visual inspection. For that purpose, the histograms for levels of the independent variable (experimental group) were drawn as illustrated in Figure 4.1 below. It was observed that the dependent variable (posttest score) was approximately normally distributed for both the control group and the treatment group.

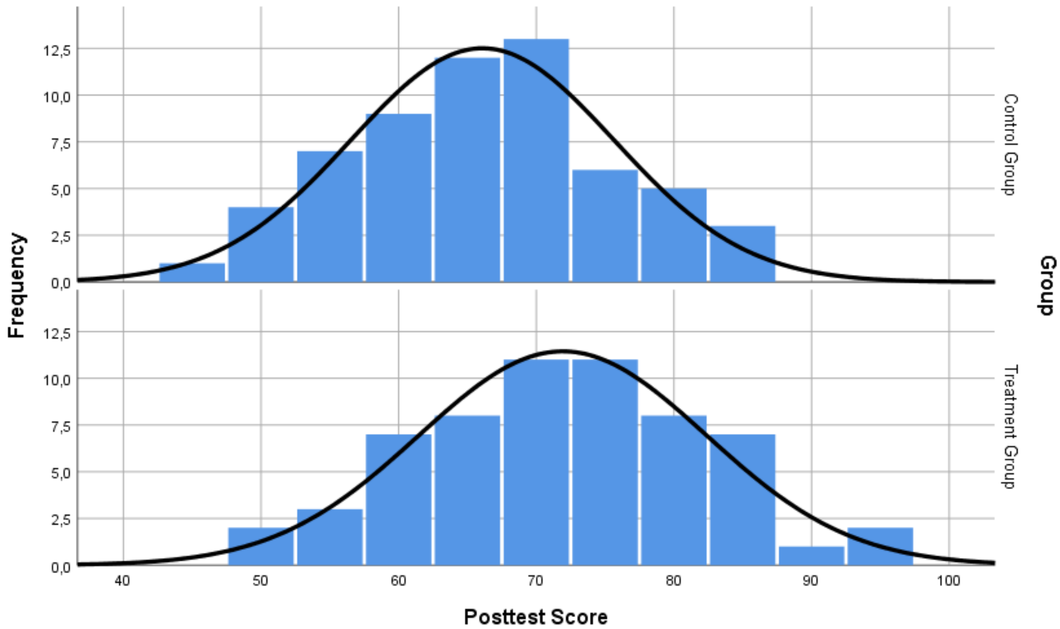

Figure 4.1. Histograms For The Posttest Scores Across Each Level Of Groups

As another form of visual inspection, Q-Q plots depicted in Figure 4.2 and Figure 4.3 were checked. It was observed that cases scattered relatively close to the diagonal line which implies that the dependent variable (posttest score) was normally distributed for each level of the independent variable (experimental group).

Figure 4.2. Q-Q Plot Of The Posttest Scores For The Control Group

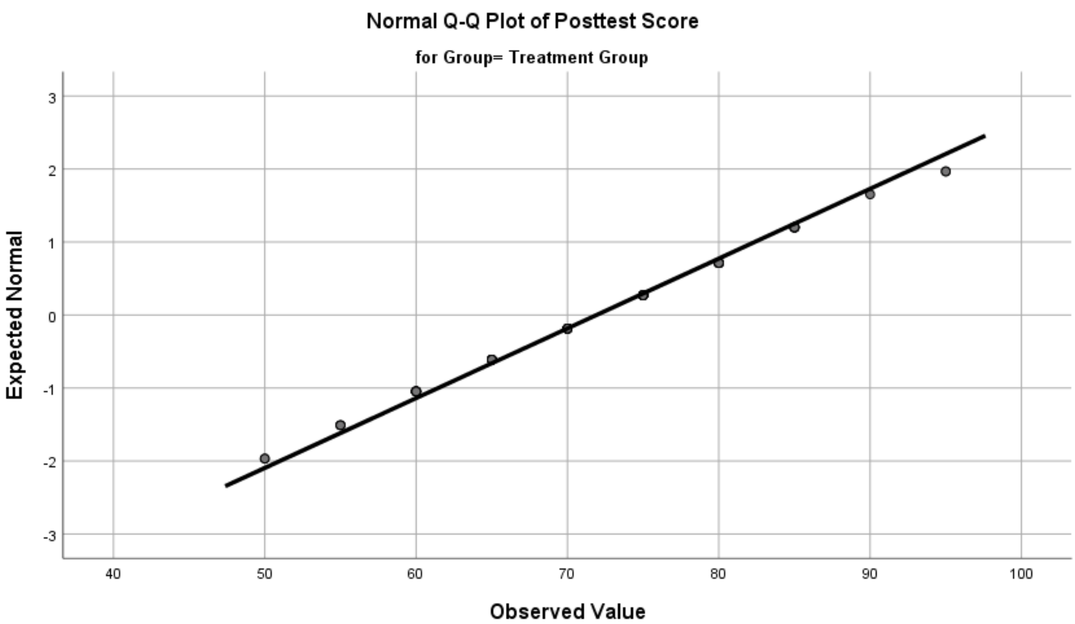

Figure 4.3. Q-Q Plot Of The Posttest Scores For The Treatment Group

Upon examining histograms, skewness and kurtosis values, Q-Q plots, results of Shapiro-Wilk's test, and results of Kolmogorov-Smirnov test, it was concluded that the normality assumption was not violated.

b) Linearity

It is assumed that "the covariate is linearly related to the dependent variable within all levels of the factor" (Green & Salkind, 2005).

Figure 4.4 illustrates the relationship between the covariate and the dependent variable.

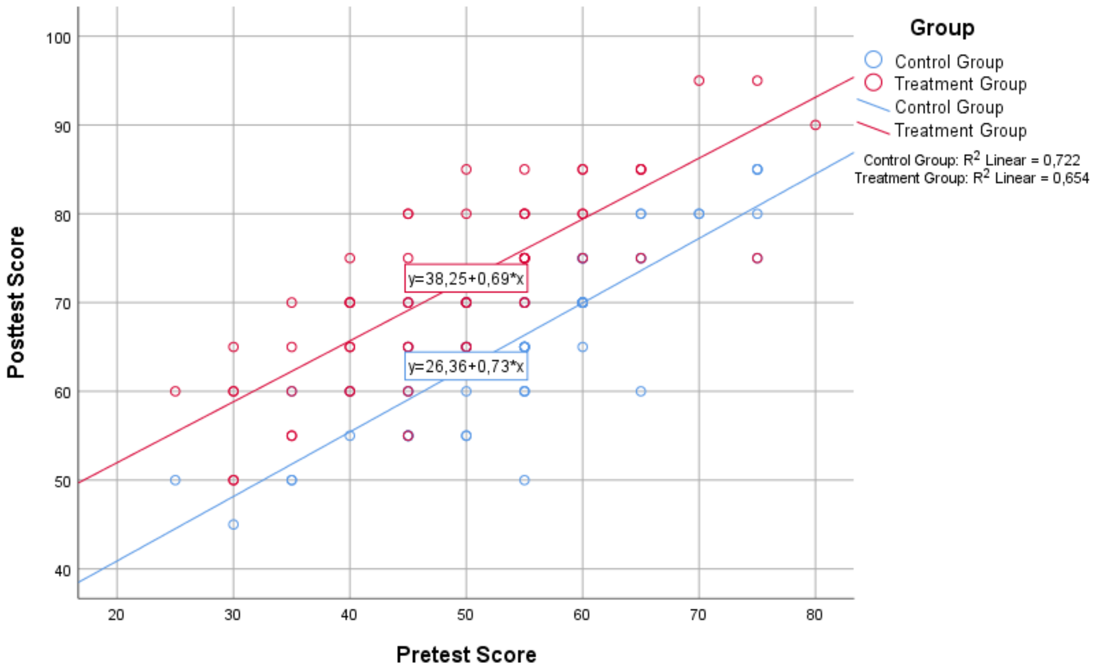

Figure 4.4. Relationship Between Pretest And Posttest Scores

It can be seen from the scatterplot that the relationship between the covariate (Pretest Score) and the dependent variable (Posttest Score) is linear and thereby the statistical power of the test is not reduced (Tabachnick & Fidell, 2007).

c) Homogeneity Of Variances

It is assumed that the dependent variable has the same variance across all comparison groups (Green & Salkind, 2005).

In order to check this assumption, Levene's test for equality of variances was carried out. The F-Test yielded that the homogeneity of variances assumption was not violated, $F(1, 118) = 3.48$, p: .06 > .05.

c) Homogeneity Of Regression Slopes

It is assumed "the weights or slopes relating the covariate to the dependent variable are equal across all levels of the factor" (Green & Salkind, 2005).

To test the homogeneity of the regression, a model was specified that includes the interaction between the covariate (pretest score) and independent variable (experimental group). The F-Test indicated that the homogeneity of regression slopes assumption was not violated, $F(1, 118) = 0.21$, p: .65 > .05. Hence, the relationship between the covariate (pretest score) and the dependent variable (posttest score) did not differ significantly as a function of the independent variable (experimental group).

4.1.3 One-Way ANCOVA

After ensuring that none of the underlying assumptions for one-way ANCOVA was violated, the analysis was conducted to evaluate whether there is a significant mean difference in posttest scores across experimental groups while holding the variation resulting from the pretest scores constant.

Initially, the descriptive statistics were calculated for ANCOVA as presented in Table 4.4.

Table 4.4 Descriptive Statistics For ANCOVA: Posttest Scores

Experimental Groups	*N*	*M*	*SD*
Control Group	60	66.08	9.57
Treatment Group	60	71.92	10.46

Subsequently, ANCOVA results were interpreted to address the first research question. Table 4.5 below provides the summary of ANCOVA results.

Table 4.5 Summary Of One-Way ANCOVA Results For Achievement Tests

Source	*SS*	*df*	*MS*	*F*	η^2
Covariate	8117.933	1	8117.933	253.873*	.68
Between	2706.258	1	2706.258	84.633*	.42
Within (Error)	3741.234	117	31.976		
Total	12880.000	120			

*p < .05

ANCOVA results showed that the covariate variable pre-test score is significant, $F(1,117) = 253.87$, $p < .05$. In addition, there was a significant mean difference in post-test scores across adjusted means of experimental groups, $F(1,117) = 84.63$, $p < .05$. Therefore, it was inferred that adjusted means are significantly different from each other.

Providing that the independent variable (experimental group) has only two levels, any Post-Hoc comparison was not necessary. When the adjusted means for experimental groups were inspected, it was found out that the treatment group has a higher adjusted mean of posttest scores (M = 73.88, SE = 0.74) compared to the control group (M = 64.12, SE = 0.74) as shown in Table 4.6.

Table 4.6 Adjusted Means For Posttest Scores Across Experimental Groups

Experimental Group	*M*	*SE*
Control Group	64.12	0.74
Treatment Group	73.88	0.74

One-way ANCOVA analysis yielded that the experimental treatment had a significant effect after adjusting for the confounding factor. To evaluate the significance of the effect, the partial η^2 value of the independent variable (see Table 4.5) must be interpreted (Field, 2009; Green & Salkind, 2005). Since the analysis examined only one effect, the η^2 value and the partial η^2 value are equal (Field, 2009). It was observed that the factor (experimental group) had a large effect size, partial η^2 = .42 which is greater than .14 (Green & Salkind, 2005, p. 210). For the case of one-way ANCOVA, Field (2009) states that the η^2 value is the r^2 value as well. Therefore, it indicates the proportion of total variance explained by an effect. Correspondingly, it can be inferred that the treatment on experimental groups can explain 42% of the variance in participants' posttest scores.

Consequently, it was noted that the statistical analysis showed that participating in the version of the course which was redesigned according to Clark's (2011) technical training design guidelines produced posttest scores with a significantly higher mean compared to participating in the original version of the course which was designed according to ADDIE model while holding the effect of pretest scores constant. The effect of the treatment was found to be large.

In the conclusion, the answer for the first research question was decided as follows:

"Yes. The redesigned course increased post-test achievement scores after adjusting for pre-test achievement scores".

4.2 Results On Error Counts

The second research question was addressed through inferential statistics methods as explained below.

4.2.1 Determining The Analysis Method

Kirkpatrick's (1959) four levels of training evaluation model suggests that the impact of training activities on organizational level results must be examined in order to reveal whether the training can enable participants to transfer what they learned into workplace context. In line with that, the second research question of the current study is determined as: “Is there a significant difference between the groups in terms of error counts recorded after the course while holding the error counts recorded before the course constant?”

The subject matter expert and several consulted supervisors raised a particular concern about measuring the effect of the training on technicians’ post-course performance in terms of the errors they make in solid rivet operations. They highlighted the fact that some of the participants might be very experienced workers whereas some of them can be in their initial years of solid rivet work. It is reportedly known that experienced workers are expected to make fewer operational errors on average. Also, certain technicians are known for being “gifted” in that particular operation. Therefore, specific participant profiles are expected to make fewer errors compared to others because of the issues unrelated to this study.

The concern of the prior performance status led to the decision that it is a very likely extraneous factor for post-course error counts of the participants. Accordingly, the pre-course error counts were a candidate for a good covariate. Before proceeding to the ANCOVA analysis, the pre-course error counts mean scores of the experimental groups were compared through an independent samples t-test. In this way, it was checked if there is a significant mean difference across groups in terms of the possible covariate.

The independent samples t-test analysis showed that the control group had a higher mean score in the pre-course error counts (M = 14.45, SD = 5.52) than the treatment group (M = 11.32, SD = 4.81). This difference was significant $t(118) = 3.31$, p: .00 < .05 and it did represent a medium effect size d = .60. as presented in Table 4.7.

Table 4.7 Independent Samples t-test Results For Pre-Course Error Counts

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
Mean difference between control and treatment groups	Equal variances assumed	1.02	.31	3.31	118	.00

Providing that experimental groups had significantly different mean scores in the pre-course error counts, the variance resulting from the pre-course error counts should be removed from the variance in post-course error counts in order to eliminate the confounding effect. Correspondingly, Green & Salkind (2005) suggest that one-way ANCOVA is an appropriate analysis for studies with a pre-test as well as the random assignment of subjects to levels of the independent variable which is the case for the present study. Table 4.8 presents the variables included in the ANCOVA and their descriptions.

Table 4.8 List Of Variables And Descriptions For ANCOVA: Post-course Error

Variable name	Description of the variable
Group	Experimental group (1: control group, 2: treatment group)
Post-course Error Count	Number of operational errors related to solid rivet installations after the training course
Pre-course Error Count	Number of operational errors related to solid rivet installations before the training course

4.2.2 Checking The Underlying Assumptions

After deciding the covariate, underlying assumptions of the ANCOVA were checked.

a) Normality

It is assumed that “the population distribution on the dependent variable is to be normally distributed for any specific value of the covariate within each cell defined by independent variables” (Green & Salkind, 2005).

First of all, the Kolmogorov-Smirnov test indicated that posttest scores follow a normal distribution both for the control group, $D(60) = 0.09$, p: $.20 > .05$ and the treatment group, $D(60) = 0.10$, p: $.20 > 0.05$. Also, the Shapiro-Wilk’s test showed that posttest scores are normally distributed for both the control group, $W(60) = 0.98$, p: $0.39 > .05$ as well as the treatment group, $W(60) = 0.97$, p: $0.22 > .05$.

Additionally, z-scores are calculated for skewness and kurtosis values of the posttest scores. It was found out that the z-value of skewness for the control group is -0.16, the z-value of skewness for the treatment group is 0.90, the z-value of kurtosis for the control group is -1.16, and the z-value of kurtosis for the treatment group is -1.17. All four z-values fall between the acceptable range of -1.96 and +1.96 (Field, 2009) as shown in Table 4.9 below.

Table 4.9 Skewness And Kurtosis Z-Scores For Post-course Error Counts

Experimental Group	Skewness	Kurtosis	Acceptable Range
Control	-0.16	-1.16	Between -1.96 and +1.96
Treatment	0.90	-1.17	Between -1.96 and +1.96

The normality assumption was also tested through visual inspection. For that purpose, the histograms for levels of the independent variable (experimental group) were drawn as illustrated in Figure 4.5 below. It was observed that the dependent variable (post-course error count) was approximately normally distributed for both the control group and the treatment group.

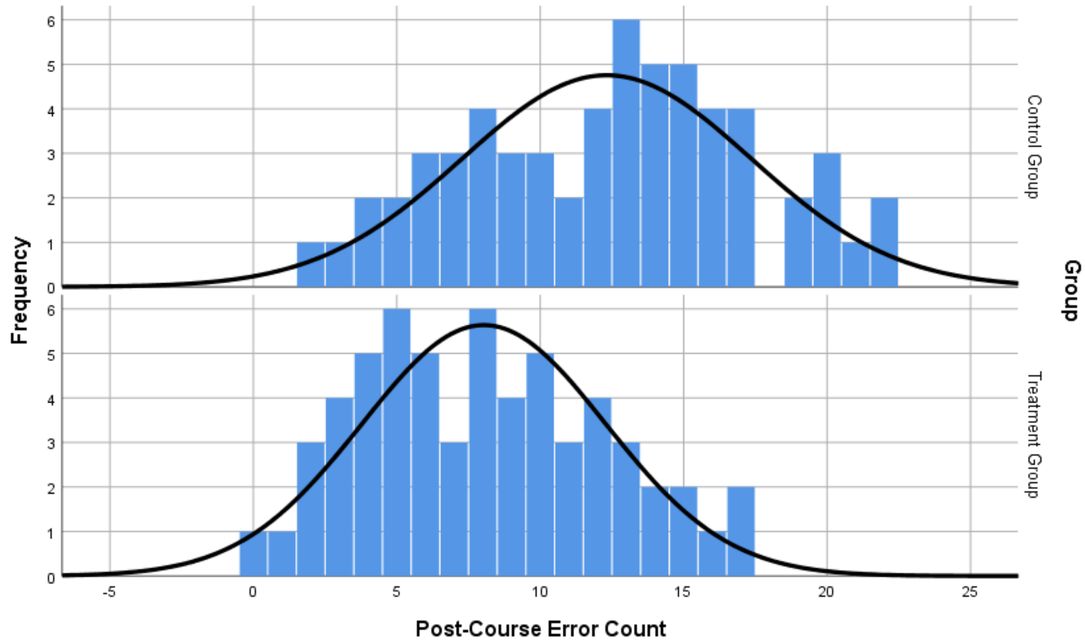

Figure 4.5. Histograms For Post-course Error Across Each Level Of Groups

As another form of visual inspection, Q-Q plots depicted in Figure 4.6 and Figure 4.7 were checked. It was observed that cases scattered relatively close to the diagonal line which implies that the dependent variable (post-course error count) was normally distributed for each level of the independent variable (experimental group).

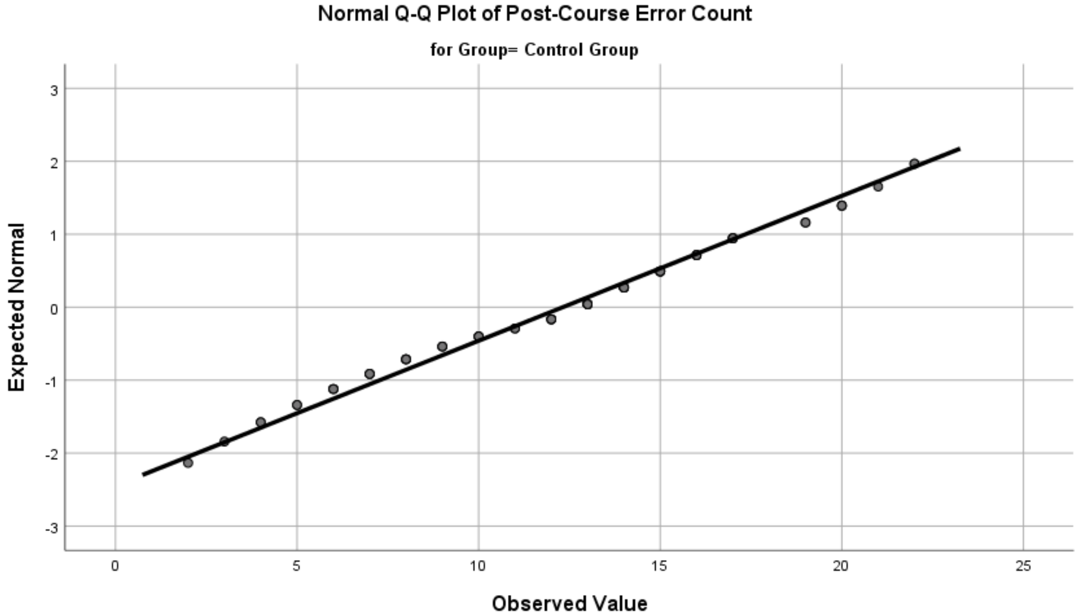

Figure 4.6. Q-Q Plot Of The Post-course Error Count For The Control Group

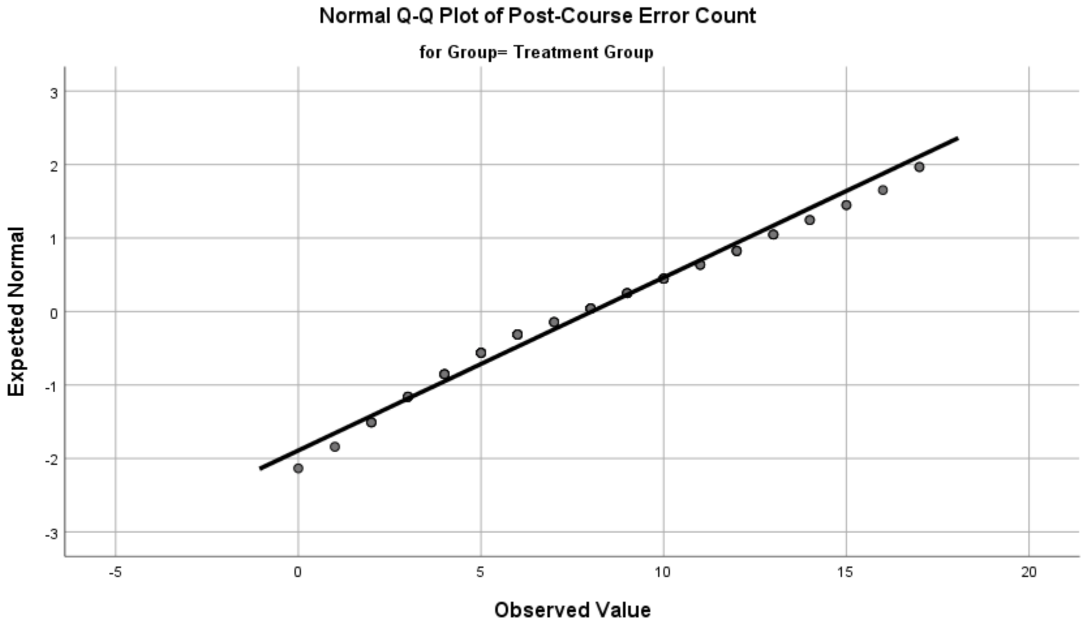

Figure 4.7. Q-Q Plot Of The Post-course Error Count For The Treatment Group

Upon examining histograms, skewness and kurtosis values, Q-Q plots, results of Shapiro-Wilk’s test, and results of Kolmogorov-Smirnov test, it was concluded that the normality assumption was not violated.

b) Linearity

It is assumed that "the covariate is linearly related to the dependent variable within all levels of the factor" (Green & Salkind, 2005).

Figure 4.4 illustrates the relationship between the covariate and the dependent variable.

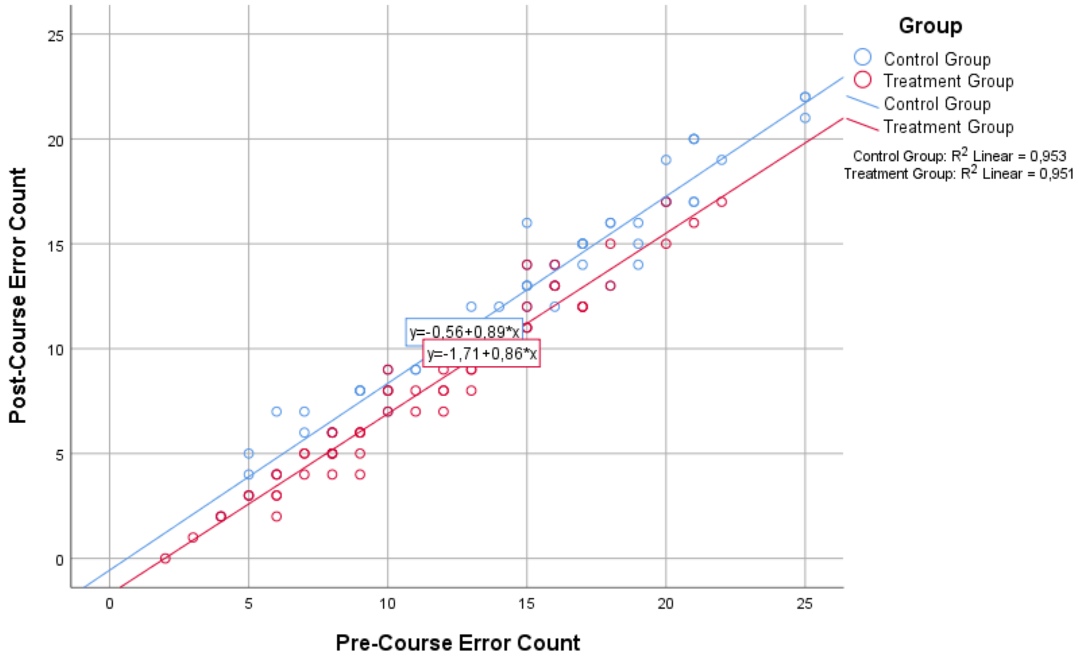

Figure 4.8. Relationship Between The Pre-course and Post-course Error Counts

It can be seen from the scatterplot that the relationship between the covariate (pre-course error count) and the dependent variable (post-course error count) is linear and thereby the statistical power of the test is not reduced (Tabachnick & Fidell, 2007).

c) Homogeneity Of Variances

It is assumed that the dependent variable has the same variance across all comparison groups (Green & Salkind, 2005).

In order to check this assumption, Levene's test for equality of variances was carried out. The F-Test yielded that the homogeneity of variances assumption was not violated, $F(1, 118) = 0.39$, p: .53 > .05.

c) Homogeneity Of Regression Slopes

It is assumed "the weights or slopes relating the covariate to the dependent variable are equal across all levels of the factor" (Green & Salkind, 2005).

To test the homogeneity of the regression, a model was specified that includes the interaction between the covariate (pre-course error count) and independent variable (experimental group). The F-Test indicated that the homogeneity of regression slopes assumption was not violated, $F(1, 118) = 1.69$, p: $.41 > .05$. Hence, the relationship between the covariate (pre-course error count) and the dependent variable (post-course error count) did not differ significantly as a function of the independent variable (experimental group).

4.2.3 One-Way ANCOVA

After ensuring that none of the underlying assumptions for one-way ANCOVA was violated, the analysis was conducted to evaluate whether there is a significant mean difference in post-course error counts across experimental groups while holding the variation resulting from the pre-course error counts constant.

Initially, the descriptive statistics were calculated for ANCOVA as presented in Table 4.10.

Table 4.10 Descriptive Statistics For ANCOVA: Post-course Error Counts

Experimental Groups	*N*	*M*	*SD*
Control Group	60	12.32	5.03
Treatment Group	60	8.03	4.25

Subsequently, ANCOVA results were interpreted to address the second research question. Table 4.11 below provides the summary of ANCOVA results.

Table 4.11 Summary Of One-Way ANCOVA Results For Error Counts

Source	*SS*	*df*	*MS*	*F*	η^2
Covariate	2436.927	1	2436.927	2337.258*	.95
Between	64.456	1	64.456	61.820*	.35
Within (Error)	121.989	117	1.043		
Total	15533.000	120			

*p < .05

ANCOVA results showed that the covariate variable pre-course error count is significant, $F(1,117) = 2337.26$, $p < .05$. In addition, there was a significant mean difference in post-course error counts across adjusted means of experimental groups, $F(1,117) = 61.82$, $p < .05$. Therefore, it was inferred that adjusted means are significantly different from each other.

Providing that the independent variable (experimental group) has only two levels, any Post-Hoc comparison was not necessary. When the adjusted means for experimental groups were inspected, it was found out that the treatment group has a lower adjusted mean of post-course error counts ($M = 9.41$, $SE = 0.13$) compared to the control group ($M = 10.94$, $SE = 0.13$) as shown in Table 4.6.

Table 4.12 Adjusted Means For Post-course Error Across Experimental Groups

Experimental Group	*M*	*SE*
Control Group	10.94	0.13
Treatment Group	9.41	0.13

One-way ANCOVA analysis yielded that there is a significant difference in the dependent variable following the treatment after adjusting for the confounding factor. As explained in subsection 4.1.3, the partial η^2 value of the independent variable (see Table 4.11) must be interpreted (Field, 2009; Green & Salkind, 2005).

Since the analysis examined only one effect, the η^2 value and the partial η^2 value are equal (Field, 2009). It was observed that the factor (experimental group) had a large effect size, partial η^2 = .42 which is greater than .14 (Green & Salkind, 2005, p. 210). For the case of one-way ANCOVA, Field (2009) states that the η^2 value is the r^2 value as well. Therefore, it indicates the proportion of total variance explained by an effect. Correspondingly, it can be inferred that the treatment on experimental groups can explain 35% of the variance in participants' post-course error counts.

Consequently, it was noted that the statistical analysis showed that participants who took the version of the course which was redesigned according to Clark's (2011) technical training design guidelines had a significantly lower mean of operational error counts after the course compared to those who took the original version of the course which was designed according to ADDIE model while holding the effect of pre-course error counts constant. The effect size of the mean difference was found to be large.

In the conclusion, the answer for the second research question was decided as follows:

"Yes. There is a significant mean difference between the control group and the treatment group in terms of error counts recorded after the course while holding the error counts recorded before the course constant"

4.3 Results On Participant Reactions

The New World Level 1 Reaction Sheet (Kirkpatrick, 2008) was treated as a closed-ended interview since it is not a psychometric scale that measures certain constructs. Correspondingly, participant responses to the questionnaire were explored and summarized through descriptive statistics.

The items in the questionnaire are organized under several categories such as program objectives, course materials, content relevance, facilitator knowledge, facilitator delivery, facilitator style, program evaluation, breaks, and facility. Each item was rated by the participants using the following options: Strongly Disagree (1), Disagree (2), Agree (3), and Strongly Agree (4).

Table 4.13 below shows the percentages of responses across categories after combining “Strongly Disagree” and “Disagree” options under the label “Negative” and combining “Strongly Agree” and “Agree” options under the label “Positive”.

Table 4.13 Distribution Of Positive And Negative Reactions Across Categories

	Control Group		Treatment Group		Number of Responses Per Group
Item Category	*Positive* %	*Negative* %	*Positive* %	*Negative* %	*N*
Program objectives*	55.56	4.44	76.11	23.89	180
Course materials*	60.83	39.17	77.50	22.50	120
Content relevance*	58.33	41.67	81.67	18.33	60
Facilitator knowledge	78.33	21.67	79.17	20.83	120
Facilitator delivery	65	35	71.25	28.75	240
Facilitator style	71.11	28.89	73.33	26.67	180
Program evaluation*	58.33	41.67	79.17	20.83	120
Breaks	81.67	18.33	83.33	16.67	60
Facility	75.56	24.44	78.33	21.67	180

*Categories closely related to treatment conditions

Upon reviewing the responses over the reaction sheet, it was observed that participants from the treatment group provided more positive reactions (76.43% overall) than the participants from the control group (66.75% overall).

Item categories program objectives, course materials, content relevance, and program evaluation were closely related to dimensions of the treatment such as writing learning outcomes, creating information displays, classifying and assigning importance content pieces based on their types, selecting instructional methods based on content types and writing assessment items based on content types. On the other hand, the item categories facilitator, knowledge, facilitator delivery, facilitator style, breaks, and facility were not directly addressed through treatment conditions. These issues were either attempted to be equalized across groups or they were completely out of concern for this study.

It was seen that the difference between groups' positive reaction percentages was considerably high for treatment-related item categories ranging from 16.67% to 23.33%. All differences were in favor of the treatment group. However, it was observed that the difference between groups' positive reaction percentages was minimal for unrelated or indirectly related item categories ranging from 0.83% to 6.25%. All differences were again in favor of the treatment group. Table 4.14 presents the comparison of positive response percentages across groups with respect to the item categories and their relation to the treatment conditions.

Table 4.14 Positive Reaction Percentages For Experiment Groups: Comparison

Category Status For Treatment Conditions	Item Category	Control Group Positive %	Treatment Groıup Positive %	Difference
Categories closely related to the treatment	Content relevance	58.33	81.67	23.33
	Program evaluation	58.33	79.17	20.83
	Program objectives	55.56	76.11	20.56
	Course materials	60.83	77.50	16.67
Categories unrelated or indirectly related to the treatment	Facilitator delivery	65.00	71.25	6.25
	Facility	75.56	78.33	2.78
	Facilitator style	71.11	73.33	2.22
	Breaks	81.67	83.33	1.67
	Facilitator knowledge	78.33	79.17	0.83

Thereby, it can be inferred that treatment conditions positively altered participants' reactions towards the training at noticeable levels for directly related issues. The treatment group reported higher percentages of positive reactions for issues unrelated or indirectly related to the treatment conditions as well. But the differences compared to the control group in the percentage of positive responses were minimal for those categories.

CHAPTER 5

DISCUSSION AND CONCLUSION

This chapter of the dissertation highlights the major findings of the study in order to discuss them in the light of relevant literature. Additionally, the chapter provides implications and certain suggestions for both research and practical purposes.

5.1 Overview Of The Study

The present study was conducted to investigate the effects of following Clark's (2011) technical training design guideline in the context of the Turkish Aerospace Academy. The effect was examined in terms of participant achievement in solid rivet application, impact on the number of operational errors made by participants, and also the reactions toward the training. The current study employed an experimental research design in the form of a “post-test only” approach. Correspondingly, participants were randomly assigned to control and treatment groups. The treatment conditions involved the redesign of a particular technical training course. The control group was exposed to the original version of the course whereas the treatment group was exposed to the redesigned version which applied Clark's (2011) guidelines. In the course of the study, two achievement tests were prepared for solid rivet applications. Content validity and criterion validity measures were established for both tests. Participants took the first test as a pre-course exam and took the second test as a post-course exam. Participants also filled out The New World Level 1 Reaction Sheet to report on their reactions towards the training. The effect of the course redesign treatment on achievement levels and also on the number of operational errors made was examined through statistical analyses. The participant reactions were also compared across experimental groups. The variables concerned in the study were intended to be evaluated corresponding to Kirkpatrick's (1959) four levels of training evaluation.

5.2 Discussion Of The Findings

This subsection of the study summarizes each major findings in line with the research questions. Also, the research attempts to draw conclusions from findings regarding the related literature.

5.2.1 Effect On Reactions

Kirkpatrick's (1959) four levels of training evaluation model states that the initial step of the training evaluation should involve examining how participants react to the activity. Reactions in level 1 refer to the degree to which participants find the training “favorable, engaging and relevant” to their jobs (Kirkpatrick & Kirkpatrick, 2016) Accordingly, the present study collected data on participant reactions through The New World Level 1 Reaction Sheet (Kirkpatrick, 2008).

It turned out that participants in the treatment group had a larger proportion of positive reactions in terms of content relevance, program evaluation, program objectives, and course materials compared to the participants in the control group. On the other hand, the difference in the proportion of positive reactions across groups was minimal for unrelated or indirectly related issues like facilitator performance, breaks, or facility conditions. This finding can be interpreted so that treatment conditions changed participant reactions positively without majorly affecting issues that were intended to be fixed for all groups. Although learners’ affirmative reactions towards an instructional activity do not guarantee their learning or ability to transfer (Clark, 2019; Kirkpatrcik & Kirkpatrick, 2014), receiving positive participant reactions is a promising indication for achieving learning and transfer. Therefore, reaction sheet results can be used to support the argument that Clark's (2011) guidelines provided positive results in level 1 evaluation (Kirkpatrick, 1959) by making a technical training course more appreciative, appealing, and relatable for the participants. This conclusion provides a reply to the third research question of this study as well.

Another concern for level 1 evaluation practices is that they need to be practical and cost-efficient since they do not contribute to the ROE in a meaningful amount (Kirkpatrcik & Kirkpatrick, 2014). Therefore, the present study limited its efforts for level 1 to a reaction sheet and allocated further recourses for higher levels of training evaluation.

5.2.2 Effect On Achievement

The second level in Kirkpatrick's (1959) four levels of training evaluation model is called “learning”, and accordingly, it refers to measuring whether participants acquire target knowledge and skills through a particular training activity. For this purpose, the current study collected data on participant achievement in solid rivet application through a pair of tests. Clark (2011) points out that skill acquisition is at the heart of any technical training and thence instructional design, resource management, and evaluation activities must be adjusted to reflect that fact. This means technical training courses must focus on enabling participants to be able to perform target skills and imparting knowledge only when it is essential for that performance. Similarly, Knowles & Hartl (1995) characterize technical training such that it concentrates on teaching an exact skill, conducting particular procedures, and aiming to facilitate precise performances. The skill-centered approach is already reflected in Clark's (2011) guidelines. Furthermore, the evaluation instruments, namely the exams, were also designed for addressing skill acquisition through hands-on performance examination and items that test only the knowledge required for application.

The main focus of the level 2 evaluation efforts for this study was to reveal if treatment conditions lead to higher achievement for participants compared to a traditionally (the ADDIE Model) designed course. The findings showed that the interpretation of Clark's (2011) guidelines yielded a statistically significant increase in achievement even after controlling for the prior achievement levels of the participants. Since the tests combine written and performance-based tasks, this increase in achievement reflects both knowledge and skill acquisition.

Clark (2011) states that her guideline is composed of evidence-based methods and principles which she reviewed on several occasions (Clark, 2008, 2019). Therefore, suggestions in this study's interpretation of the content-performance matrix (see Appendix H) rely on Clark's (2019) evidence inquiries. Findings on increased achievement can be considered as another piece of evidence for effectivity of these guidelines for the case of the Turkish Aerospace Academy. As explained in the "1.4 Significance Of The Study" subsection, the present study was motivated by actual challenges from the Turkish Aerospace Academy. A major challenge was the lack of a specific model that is known to work for the TAI context or technical training context. The finding on the increased achievement can be used as an indicator to apply the approach in this study to improve instructional quality and outcomes for the Turkish Aerospace Academy.

The alteration in achievement scores can also be associated with the role of practice, to some extent. On that point, the practice refers to any activity that requires participant performance, either reasoning or physical execution, with high relevance to authentic job tasks. In the original version of the course, 7 out of 17 fundamental content pieces were addressed with any practice-involved learner engagement. However, the redesigned course included 13 practice-involved content pieces out of

17. In addition, the practice-involved activities were enhanced for 4 of the content pieces that were already addressed in the original course. Table 5.1 below summarizes the status of each fundamental content piece in terms of practice involvement. Details of the practice-related adjustments can be found in the treatment matrix (see Appendix İ) under the “Practice Exercises” column.

Table 5.1 Practice Involvement For Fundamental Content Pieces

Fundamental Content Piece	Original Course	Redesigned Course	Enhancement
General description	No practice	No practice	None
Specifications	No practice	Practice assigned	None
Standards	No practice	No practice	None
Rivet types	Practice assigned	Practice assigned	Enhanced
Rivet definition protocol	Practice assigned	Practice assigned	Enhanced
Rivets on technical drawing	No practice	Practice assigned	None
Heat work	No practice	Practice assigned	None
Spacing and distances	No practice	Practice assigned	None
Hole diameters	No practice	Practice assigned	None
Rivet length	Practice assigned	Practice assigned	Enhanced
Equipment and tools	No practice	Practice assigned	None
Hole preparation	Practice assigned	Practice assigned	None
Countersinking	Practice assigned	Practice assigned	None
Critical warnings	No practice	No practice	None
Audit criteria	Practice assigned	Practice assigned	Enhanced
Trimming	No practice	No practice	None
Removal of non-conforming installations	Practice assigned	Practice assigned	None

Consequently, the redesigned course had a highly practice-oriented environment. The increase in achievement preceded by the increasing of practice involved components of the course is consistent with previous findings from the literature. Garavan (1997) draws attention to the mechanistic nature of technical training which heavily relies on learning-by-doing. Likewise, (Buckley & Caple, 2009) underline that the ultimate goal of technical training is to teach applicable skills which necessitate the application of the skills in the training. Williams (2001) addresses the issue from a different aspect. She reports that technical trainers selected from experienced practitioners are more likely to succeed because they can confidently lead the application or exercise of the skills which is crucial for the success of the course. Providing that the training literature agrees on the importance of the practice for technical training, the link between increased practice exercises and higher post-course achievement scores can be put into perspective. However, the real significance of this finding derives from the fact that this study provides a working example on how to increase practice involvement for specific cases by means of Clark's (2011) prescriptive guidelines.

As the last point in case, increased achievement through the treatment is a promising sign in terms of achieving the far transfer of learning although it does not guarantee the transfer (Kirkpatrcik & Kirkpatrick, 2014; Williams & Nafukho, 2015). Thus, the statistically significant increase in achievement after the course provides a reply to the first research question of this study as well.

5.2.3 Effect On Operational Errors

The highest level in Kirkpatrick's (1959) training evaluation model is level 4 which is titled “results”. This level of evaluation investigates whether the training yielded any impact on organizational objectives (Kirkpatrcik & Kirkpatrick, 2014). The ultimate goal of any training activity is to create value in terms of business objectives

(Phillips, 2010). Therefore, the outcome of technical training at this level is of utmost importance. To shed light on that, this study collected data through the organizational ERP software in terms of the number of errors made by participants before and after the treatment. The errors concerned were only the ones associated with the learning outcomes of the selected course. Hence, the error counts were treated as performance indicators which they are. Because the organization already used them as key performance indicators or KPIs.

The statistical analysis of error counts showed that there is a statistically significant difference between means of post-course error counts across experimental groups. It was observed that the treatment group conducted fewer errors compared to the control group even after controlling for their error records before the course. This finding can be interpreted so that the redesigned course led to a better transfer of learning into the workplace.

Detterman (1993) argues that far transfer is rarely achieved through training activities based on his review of the literature. He suggests that this is due to the lack of appropriate efforts on level 3 or level 4 evaluation. The same criticism was raised by many others repeatedly (Kirkpatrcik & Kirkpatrick, 2014; Phillips, 2010; Twitchell, Holton & Trott, 2000). However, several researchers highlight that it is relatively more feasible to associate training outcomes to business objectives in the case of technical training as it focuses on operational skills that are inherently linked to business goals (Combs & Davis, 2010; Swanson & Holton, 2001). The present study provides a finding concerning operational effectiveness in the form of error frequency. The tolerance for operational errors in the aerospace industry is extremely low since the consequences are often irreversible. Therefore, reducing the number of operational errors is always a primary concern of aerospace companies. It can be concluded that the finding of decreased error counts due to the treatment is an important case for level 4 evaluation and occurrence of far transfer.

The transfer of learning can either improve or weaken the outcome in the workplace based on its effect. Providing that, the transfer can be classified as positive or negative (Perkins & Salomon, 1992). From this vantage point, it can be concluded that the present study resulted in positive transfer in the TAI context.

There are various approaches for explaining the emergence of transfer of learning. Perkins & Salomon (1992) introduces a framework on conditions of transfer. Three out of five conditions are particularly relevant for this study which are “thorough and divers practice”, “using a metaphor or analogy” along with “explicit abstraction”. These three factors are reportedly crucial in achieving the transfer of learning. As mentioned earlier, Clark's (2011) guidelines helped making the course highly practice-oriented. The treatment involved both introduction of several new practice exercises and also enhancement of existing ones. That is in line with the expectation of thorough and diverse practice. Moreover, an analogy was utilized as well in accordance with the guideline (see Appendix İ, Subtopic Specifications). Lastly, the participants were encouraged and directed to reflect on their reasoning for tasks like identifying rivets, distinguishing specifications, or interpreting code strings. Also, the instructor presented participants with certain problem cases and asked them to find the solution by highlighting their rationale (see Appendix İ, Column Practice Exercises). That is in line with the expectation of explicit abstraction. Consequently, it can be inferred that the utilization of three key factors in the redesign of the course resulted in far transfer. Thence, the present study provides a detailed working example for achieving transfer in the context of TAI considering that this approach enabled positive transfer.

Finally, the finding of the decreased mean of error counts on the treatment group provides a reply to the second research question of this study as well.

5.3 Conclusion And Implications

Training has been recognized as an instrument of organizational development for decades. Ironically, misalignment with organizational objectives emerged as a chronic problem in the field. Eventually, the value of training is subject to questioning across different organizations. This is partially due to the large discrepancy between the training literature and common mispractices within the community that relies on baseless conventions. Technical training had its share from this unpleasant trend although it was relatively more compatible with the expectation of improving business objectives. Furthermore, another issue for technical training is the lack of research concerning design and evaluation with respect to the unique characteristics of technical training.

The present study addressed these issues to a certain degree in a particular context. First of all, the current study employed an evidence-based approach instead of misconceptions and insubstantial principles. The technical training guideline followed in the study relies on previous research and workplace examples (Clark, 2011, 2019). The primary proposition of the present study is also associated with statistical evidence. Hence, it was aimed to contribute to evidence-based instructional design efforts in the field of technical training.

Secondly, the issue of not demonstrating organizational level value was addressed through achieving level 4 or results-level evaluation (Kirkpatrick, 1959). The present study acknowledges and complies with two pivotal remarks from the literature which were generally overlooked. To begin with, the current study follows the advice of considering business objectives before the instructional design and reflect them in design, development, and evaluation preferences. This is the foundation of both Kirkpatrick's (1959) four levels of training evaluation model and Clark's (2011) technical training development guideline. Furthermore, the current study complied with a consistently repeated warning from the literature which states that participant reactions or facilitating learning are insufficient results for technical training activities. The ultimate purpose is achieving transfer of learning in order to change behavior and produce results in terms of bottom-line business objectives. Accordingly, the resources should be allocated to levels of evaluation with corresponding priorities (Kirkpatrick & Kirkpatrick, 2016). In this study, it was achieved to link the training interventions to the operational performance by relying on fundamental principles of training research.

Third and last chronic issue addressed in the present study is the unique characteristics of technical training that are oftentimes not taken into account. Technical training activities are usually designed with generic instructional design approaches which turned out to be the case for the selected course of this study. However, technical training has inherent differentiators (Combs & Davis, 2010, pp. 67-91) such as involvement of subject-matter experts, focus on applicability, fading of motor skills (Romiszowski, 1999), etc. Among many factors, one of them was particularly important for the target context of the study. That is, the majority of the technical courses in Turkish Aerospace Academy were required to be designed and delivered by occasional trainers. However, these trainers are limited in terms of their knowledge and expertise in learning sciences. Therefore, a model or tool is needed to enable them to design and deliver effective technical training. The model or tool must be straightforward and prescriptive in order to allow as many technical experts as possible to design efficient training. Correspondingly, the present study produced an interpretation of Clark's (2011) technical training design guideline for TAI technical training needs along with a working example for it.

5.3.1 Implications

The current study was motivated by actual challenges within the Turkish Aerospace Academy. Accordingly, the primary intention was to devise a tool and form an approach that is appropriate for the needs of TAI. As a result, the interpretation of the content-performance matrix (see Appendix H) was prepared. This matrix is comprised of several suggestions in a very simple language for well-defined conditions. The occasional trainer is only required to be able to break down and classify the content. Afterward, all he/she needs to do is following prescriptive recommendations for writing learning outcomes, composing information displays, selecting instructional methods, and selecting assessment methods for each content type. To ease the comprehension of the method, another matrix was also presented. The treatment matrix (see Appendix İ) includes exemplary applications for each cell of the interpretation matrix. Hence, it is possible to make sense of a particular recommendation by inspecting its corresponding treatment. In brief, an important implication of this study is the possibility of redesigning the catalog of 300 technical training utilizing the tool and example provided here. Assuming that each redesign yields increased achievement and increased operational performance, the study can pave the way for a noteworthy and cumulative training impact on organizational results for TAI.

On a different account, there was another authentic challenge in the selected context of TAI. A valid and feasible model was required to evaluate the effectiveness of massive training operations. Because the allocated resources are at high stakes although no connection could be established between invested resources and their outcomes. The present study itself is a working example in the context of TAI to show how to link training interventions with meaningful business objectives. The emphasis on pre-program consideration of organizational goals and concentrating efforts to level 4 activities can lay a foundation to generalize over the evaluation of other technical training courses. A reliable training evaluation approach can help learning and development professionals working at Turkish Aerospace Academy as well as the executives of TAI to make strategic decisions based on evidence. Thence, it can be possible to allocate resources efficiently and obtain the maximum contribution from technical training interventions. In addition, an effective evaluation approach can be useful for addressing the audits and inquiries of both clients and regulatory authorities by providing them with consistent and justified results. The relation between technical training and operational outcomes is extremely important for those stakeholders.

Lastly, the present study can be considered from a different perspective. It was mention earlier that technical training design and evaluation literature were surprisingly limited within the large body of knowledge concerning training in general. The current study is a contribution in terms of contextualizing one of these comprehensive guidelines. Since they are intended to be guides for a large target audience they are inherently general and diverse. Herewith, Clark's (2011) technical training design guideline was interpreted for a particular context; a large-scale aerospace company in Turkey. From this vantage point, the present study is one of the few examples if not the only one for contextualizing Clark's (2011) approach. Thus, both researchers and practitioners who are interested in a similar context can make inferences from this study instead of directly concerning the general guideline.

This dissertation draws attention to a number of research directions such as evidence-based instructional design, technical training design, far transfer of learning, and training evaluation. Although it has varying amounts of humble contributions to these topics, the generalizability of the results must be considered with caution. It is recommended to pay close attention to the contextual characteristics of the study before attempting to extrapolate it for any kind of implication.

5.3.2 Future Research

Delimitations and limitations of the present study were discussed under the "Results" chapter. Any research aiming to fill the gaps caused by these limitations would be a complementary contribution to this study. Other than this, the researcher identifies several ideas for future research.

It was not possible to conduct a thorough interview with the subject matter expert of this course redesign process due to time limitations and increased operational workload stemming from the COVID-19 pandemic at the time of the study. It would be enlightening to include the perspectives and experiences of occasional trainers in such a technical training design study. Their feedback on the usefulness of matrices, the general experience of following such a guideline, and the form of evaluation could help improve the overall effect of the design for the next iterations.

As mentioned under the 3.9 Delimitations and Limitations section, it was not possible within the scope of this study to conduct the planned series of interviews with supervisors of participants in order to address Kirkpatrick's (1959) Level 3 evaluation of behavioral changes. It can be recommended for future research efforts to consider a 360-degree feedback approach or using self-evaluation forms for participants when interviews are not feasible.

As Thalheimer (2018) underlines, technical training can not be confined to a single training intervention since it centers around skill acquisition. In a different research, the same approach of technical training design can be extended to post-training activities. The effect of follow-up interventions can be examined and the guideline can be updated by incorporating suggestions for post-program interventions.

The transfer of learning is beyond establishing associations between previous and new experiences. It is a product of the learner's cognitive mechanisms and hence involves personal variables as well (Baldwin & Ford, 1988). Therefore, more research on individual factors that are reportedly associated with the transfer of learning needs to be undertaken before the effect of technical training design is clearly understood.

A further study with more focus on the speed dimension of job performance in solid rivet installation operations is also suggested. The present study did not address the speed of installation in the research since it would be extremely demanding to establish a quantitative indicator for speed, ensuring the data collection, describing the success criterion which is not defined beforehand (unlike the precision factor which is already in use as a KPI).

There is a limited number of resources solely dedicated to technical training as shown in Table 2.8. This study presents a case for one of them. Further studies can address other resources in order to enable the training community to compare and contrast resources in terms of concrete findings instead of theoretical discussions.

Another call for conducting similar interpretation studies can be made as well. Upon applying the same research approach for the same guideline, the generalizability of this study can be enhanced based on common themes across similar efforts.

One last research suggestion involves transforming the matrices produced by this study into walkthrough tutorials or support systems to make them more useful and practical. In this way, logs of technical training design processes can also be stored and can later be used for analysis purposes.

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APPENDICES

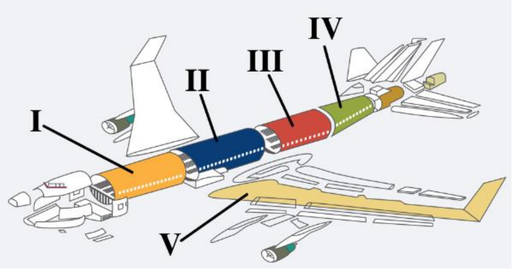
A. Pre-course Achievement Test

Bu sınav, kağıt üzerinde yanıtlanacak sorular ve bazı performans görevlerinin toplamından oluşmaktadır. Lütfen yazılı maddeler için cevaplarınızı kağıt üzerine işaretleyiniz. Sonda yer alan görev tanımlarını izleyerek gerekli işlemleri yerine getiriniz.

Sınav Süresi: 60 Dakika

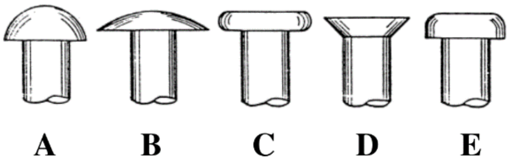
Yazılı Sorular

1. Yandaki şekli inceleyiniz. Uçağın hangi kısımları dolu gövdeli perçin uygulaması için uygundur? (Birden çok seçeneği yuvarlak içine alabilirsiniz) [İPTAL EDİLEN MADDE]



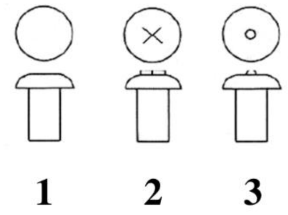
I **II** **III** **IV** **V**

2. Yandaki görseldeki dolu gövdeli perçinleri bulunuz. Birden çok seçeneği yuvarlak içine alabilirsiniz.



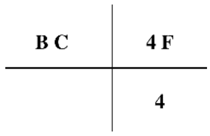
A **B** **C** **D** **E**

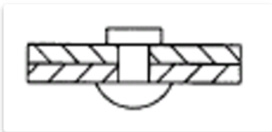
3. Yandaki görsel gösterilen tepe işaretlemelerine göre doğru perçin kodlarını yazınız.



1:___ **2:___** **3:___**

4. Yan tarafta yer alan şekilleri inceleyiniz. Soldaki diyagramın, sağdaki çizim için doğru olup olmadığını işaretleyiniz.





Doğru **Yanlış**

5. KUH projesine ait **NAS-1097-AD-5-0** kodu için, aşağıda yer alan tabloyu kullanarak perçin aralığını ve kenar mesafesini belirleyiniz.

Perçin Aralığı: ___ mm

Kenar Mesafesi:___ mm

TABLE Ⅰ, RIVET SPACING (EXCLUDES AUTOMATIC RIVETING), mm [inch]

Rivet Nominal Diameter	Engineering Standard See 3.2.4		Engineering Minimum See 3.2.4		Inspection Minimum See 3.2.5	
	A	B	A	B	A	B
1.59 [.063]	2.3 [.09]	3.0 [.12]	2.0 [.08]	3.0 [.12]	1.5 [.06]	1.5 [.06]
2.38 [.094]	3.0 [.12]	4.8 [.19]	2.8 [.11]	3.8 [.15]	2.3 [.09]	2.3 [.09]
3.18 [.125]	4.8 [.19]	6.4 [.25]	4.1 [.16]	6.4 [.25]	3.3 [.13]	3.3 [.13]
3.97 [.156]	5.6 [.22]	7.9 [.31]	4.8 [.19]	7.1 [.28]	4.1 [.16]	4.1 [.16]
4.76 [.188]	6.4 [.25]	9.4 [.37]	5.6 [.22]	7.9 [.31]	4.8 [.19]	4.8 [.19]
5.56 [.219]	7.1 [.28]	10.9 [.43]	6.4 [.25]	8.6 [.34]	5.6 [.22]	5.6 [.22]
6.35 [.250]	7.9 [.31]	12.7 [.50]	7.1 [.28]	9.4 [.37]	6.4 [.25]	6.4 [.25]
7.94 [.313]	9.4 [.37]	16.0 [.63]	8.6 [.34]	10.9 [.43]	7.9 [.31]	7.9 [.31]
9.53 [.375]	11.2 [.44]	19.1 [.75]	10.4 [.41]	12.7 [.50]	9.7 [.38]	9.7 [.38]

6. Monel malzeme üzerinde kullanılacak havşa başlı perçin için uygun perçin boyu nedir?
D cinsinden yazınız.

d =____ D

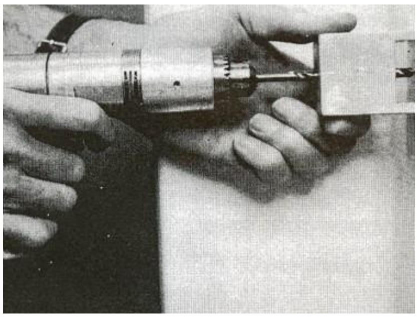
7. MS-20470-AD-4-10 kodu için kullanılması gereken perçin boyunu yazınız.

l =____ mm

8. NASM-20426-AD4-12A-5 koduyla yapılacak bir perçin çakma işlemi için kabul edilebilir taşma mesafesini hesaplayarak yazınız. (Malzeme kalınlığını 10mm alınız)

l =____ mm

9. Yan tarafta yer alan görseli dikkatlice inceleyiniz. Matkabın tutma pozisyonu uygun mudur? İşaretleyiniz.



Uygun **Uygun Değil**

10. NASM-20426-AD4-12A-5 koduyla yapılmış uygunsuz bir perçin çakma işlemine tepe kısmından müdahale etmek için doğru matkabı aşağıdaki tabloyu kullanarak seçiniz. Yanıtızı aşağıdaki boşluğa yazınız.

Drill Gun: #____

RIVET DIAMETER	DRILL GUN FOR HEAD	DRILL GUN FOR TAIL
3/32	#43	#50
1/8	#32	#40
5/32	#26	#30
3/16	#16	#20
1/4	#C	#10

11. Aşağıdaki durumlardan hangisi veya hangilerinde dolu gövdeli perçin kullanımı doğru **değildir**? (Birden çok seçeneği işaretleyebilirsiniz) [İPTAL EDİLEN MADDE 1 YERİNE EKLENEN MADDE]

A. Yük taşıyan parçaları bağlamak için
B. Sabitleme bloğu kullanmanın mümkün olmadığı yerlerde
C. Yüksek yapısal bütünlük gerektiren bölgelerde
D. Parçanın geometrisi aşırı kompleks olduğunda
E. Aluminyum parçaları birbirine bağlamak gerektiğinde

Performans Görevleri

KUH projesi kapsamında aşağıda belirtilen kodu ve 5 no'lu maddede yer alan boyut tablosunu kullanarak aşağıda sıralanan görevleri yerine getiriniz.

MS-20470-AD-4-10

1. Deliği açınız.
2. Uygun bir dolu gövdeli perçin kullanınız.
3. Perçini yerleştiriniz.

4. Tamamladığınız uygulamayı muayene ediniz.
5. Yerleştirdiğiniz perçini sökünüz. (Muayene sonucunuz ne olursa olsun sökünüz).

Not: Verilen görevleri sahada gereken tüm şartları gözeterek ve tüm adımları uygulayarak yerine getiriniz. Yukarda yer alan görev ifadelerinin, işlemin adım adım tüm safhalarını içermediğine dikkat ediniz.

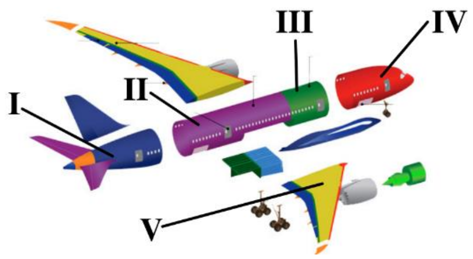
B. Post-course Achievement Test

Bu sınav, kağıt üzerinde yanıtlanacak sorular ve bazı performans görevlerinin toplamından oluşmaktadır. Lütfen yazılı maddeler için cevaplarınızı kağıt üzerine işaretleyiniz. Sonda yer alan görev tanımlarını izleyerek gerekli işlemleri yerine getiriniz. Türk Havacılık ve Uzay Sanayii Akademisi'nin "yapısal operasyonlar teknisyeni" rolüne yönelik teknik eğitim gerekliliğini sağlamış sayılmak için bu sınavdan 100 üzerinden 70 puan almanız gerekmektedir.

Sınav Süresi: 60 Dakika

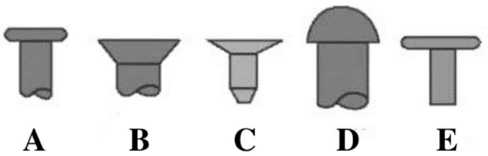
Yazılı Sorular

1. Yandaki şekli inceleyiniz. Uçağın hangi kısımları dolu gövdeli perçin uygulaması için uygun **değildir**? (Birden çok seçeneği yuvarlak içine alabilirsiniz)
[İPTAL EDİLEN MADDE]



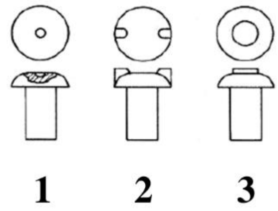
I **II** **III** **IV** **V**

2. Yandaki görseldeki dolu gövdeli perçinleri bulunuz. Birden çok seçeneği yuvarlak içine alabilirsiniz.



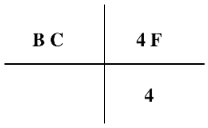
A **B** **C** **D** **E**

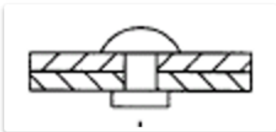
3. Yandaki görsel gösterilen tepe işaretlemelerine göre doğru perçin kodlarını yazınız.



1:___ **2:___** **3:___**

4. Yan tarafta yer alan şekilleri inceleyiniz. Soldaki diyagramın, sağdaki çizim için doğru olup olmadığını işaretleyiniz.





Doğru **Yanlış**

5. KUH projesine ait **NASM-20615-A-5-0**kodu için, aşağıda yer alan tabloyu kullanarak perçin aralığını ve kenar mesafesini belirleyiniz.

Perçin Aralığı: ___ mm

Kenar Mesafesi:___ mm

TABLE II , RIVET EDGE DISTANCE (DIMENSION "D" IN FIGURE 1), mm [inch]

Rivet Nominal Diameter	CRES Steel, Monel Rivet Material		Aluminum Alloy Rivet Material			Sheet Gage
	Eng'g Standard & Minimum	Inspection Minimum	Eng'g Standard	Eng'g Minimum	Inspection Minimum	
1.59[.063]	3.8[.15]	3.0[.12]	3.8[.15]	3.0[.12]	2.8[.11]	Under .64[.025]
					2.5[.10]	.64[.025] & Over
2.38[.094]	5.6[.22]	4.8[.19]	5.6[.22]	5.3[.21]	4.8[.19]	Under .81[.032]
				5.1[.20]	4.3[.17]	.81[.032] & Over
3.18[.125]	7.1[.28]	6.4[.25]	7.1[.28]	6.6[.26]	5.8[.23]	Under .81[.032]
				6.4[.25]	5.6[.22]	.81[.032] & Over
3.97[.156]	8.6[.34]	7.9[.31]	8.6[.34]	7.9[.31]	7.1[.28]	Under 1.02[.040]
				7.4[.29]	6.6[.26]	1.02[.040] & Over
4.76[.188]	10.2[.40]	9.4[.37]	10.2[.40]	9.4[.37]	8.6[.34]	Under 1.30[.051]
				8.6[.34]	7.9[.31]	1.30[.051] & Over
5.56[.219]	11.7[.46]	10.9[.43]	11.7[.46]	10.9[.43]	10.2[.40]	Under 1.30[.051]
				10.2[.40]	9.4[.37]	1.30[.051] & Over
6.35[.250]	13.5[.53]	12.7[.50]	13.5[.53]	12.4[.49]	11.4[.45]	Under 1.63[.064]
				11.4[.45]	10.7[.42]	1.63[.064] & Over
7.94[.313]	16.8[.66]	16.0[.63]	16.8[.66]	14.2[.56]	13.5[.53]	Under 2.06[.081]
				13.5[.53]	12.7[.50]	2.06[.081] & Over
9.53[.375]	19.8[.78]	19.1[.75]	19.8[.78]	17.3[.68]	16.5[.65]	Under 2.59[.102]
				15.7[.62]	15.0[.59]	2.59[.102] & Over

6. Aluminyum malzeme üzerinde kullanılacak bombe başlı perçin için uygun perçin boyu nedir?
D cinsinden yazınız.

d =____ D

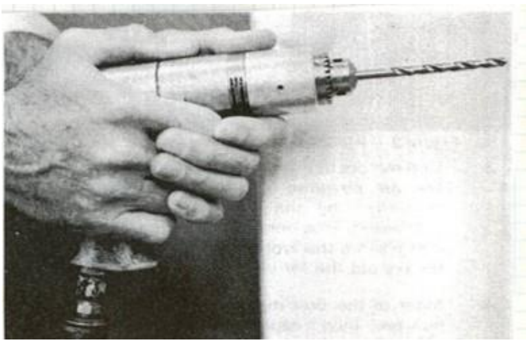
7. MS-20470-AD-4-10 kodu için kullanılması gereken perçin boyunu yazınız.

l =____ mm

8. NASM-20426-AD4-12A-5 koduyla yapılacak bir perçin çakma işlemi için kabul edilebilir perçin başı yüksekliğini hesaplayarak yazınız. (Malzeme kalınlığını 10mm alınız)

h =____ mm

9. Yan tarafta yer alan görseli dikkatlice inceleyiniz. Matkabın tutma pozisyonu uygun mudur? İşaretleyiniz.



Uygun **Uygun Değil**

10. NASM-20426-B4-12A-5 koduyla yapılmış uygunsuz bir perçin çakma işlemine dip kısmından müdahale etmek için doğru matkabı aşağıdaki tabloyu kullanarak seçiniz. Yanıtızı aşağıdaki boşluğa yazınız.

Drill Gun: #____

RIVET DIAMETER	DRILL GUN FOR HEAD	DRILL GUN FOR TAIL
3/32	#43	#50
1/8	#32	#40
5/32	#26	#30
3/16	#16	#20
1/4	#C	#10

11. Aşağıdaki durumlardan hangisi veya hangilerinde dolu gövdeli perçin kullanımı doğrudur? (Birden çok seçeneği işaretleyebilirsiniz) [İPTAL EDİLEN MADDE 1 YERİNE EKLENEN MADDE]

A. Montaj esnasında parçanın bir tarafına erişmek mümkün değilse
B. Malzeme delme işlemi yapmaya uygun olmadığında
C. Ahşap parçaları birbirine bağlamak için
D. Çok sayıda çakma ve sökme işlemine gerek duyulduğunda
E. Monel malzemeden parçaları birbirine bağlamak için

Performans Görevleri

KUH projesi kapsamında aşağıda belirtilen kodu ve 5 no'lu maddede yer alan boyut tablosunu kullanarak aşağıda sıralanan görevleri yerine getiriniz.

NASM-20615-A-5-10

1. Deliği açınız.
2. Uygun bir dolu gövdeli perçin kullanınız.

3. Perçini yerleştiriniz.
4. Tamamladığınız uygulamayı muayene ediniz.
5. Yerleştirdiğiniz perçini sökünüz. (Muayene sonucunuz ne olursa olsun sökünüz).

Not: Verilen görevleri sahada gereken tüm şartları gözeterek ve tüm adımları uygulayarak yerine getiriniz. Yukarda yer alan görev ifadelerinin, işlemin adım adım tüm safhalarını içermediğine dikkat ediniz.

C. Evaluation Guide For Both Pre-course and Post-course Achievement Tests

Item	Total Points	Criteria	Point Assigned
Written Item 1	N/A	Deleted Item	N/A
Written Item 2	5	Circling all correct rivets and not the inappropriate ones	5
Written Item 3	5	One correct code: 1 Pt | Two correct codes: 2 Pts | Three correct codes: 5 pts	5
Written Item 4	5	Correct option circled	5
Written Item 5	5	Both values are correct	5
Written Item 6	5	Correct value	5
Written Item 7	5	Correct value	5
Written Item 8	5	Correct value	5
Written Item 9	5	Correct option circled	5
Written Item 10	5	Correct option written	5
Written Item 11	5	Circling all correct options and not the inappropriate ones	5
Task Performance 1	10	Calculating & ensuring hole diameter beforehand	2
		Marking based on dimensions	2
		Selecting appropriate drill gun and lead	2
		Using drill block	2
		Deburring after drilling	2
Task Performance 2	5	Selected rivet corresponds with code string and given project specification	5
Task Performance 3	5	Using sticky tape	2
		Squeezing without wasting any rivets	3
Task Performance 4	20	Using a compass to measure exceeding rivet length	5
		Using a compass to measure rivet height	5
		Using filler gauge to measure head and tail gaps	5
		Providing a valid conclusion based on measurements	5
Task Performance 5	10	Selecting appropriate drill gun and lead	5
		Removal without cracking and scratching	5
TOTAL	**100**		**100**

D. The Content Validity Rating Form

#	Item	Is this item relevant?				Is this item essential to the domain?			Suggestions for item revision, if any.
		Not Relevant (1)	Somewhat Relevant (2)	Quite Relevant (3)	Very Relevant (4)	Essential (3)	Useful, but not essential (2)	Not necessary (1)	
1	Written Item 1								
2	Written Item 2								
3	Written Item 3								
4	Written Item 4								
5	Written Item 5								
6	Written Item 6								
7	Written Item 7								
8	Written Item 8								
9	Written Item 9								
10	Written Item 10								
11	Performance Task 1								
12	Performance Task 2								
13	Performance Task 3								
14	Performance Task 4								
15	Performance Task 5								

E. Content Validity Item Ratings For Pre-course Achievement Test

Content Validity Item Ratings For Original Item Pool

Item	Expert 1		Expert 2		Expert 3		Expert 4		Expert 5	
	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality
Written Item 1	2	1	3	2	3	2	3	2	3	3
Written Item 2	3	3	4	3	4	3	4	3	4	3
Written Item 3	3	3	4	3	3	3	3	3	4	3
Written Item 4	4	3	4	3	4	3	4	3	4	3
Written Item 5	4	3	4	3	4	3	4	3	4	3
Written Item 6	4	3	4	3	4	3	4	3	4	3
Written Item 7	4	3	4	3	3	3	4	3	4	3
Written Item 8	4	3	4	3	4	3	4	3	4	3
Written Item 9	4	3	4	3	4	3	4	3	4	3
Written Item 10	3	3	4	3	4	3	4	3	4	3
Task Performance 1	4	3	4	3	4	3	4	3	4	3
Task Performance 2	3	3	3	3	4	3	4	3	3	3
Task Performance 3	4	3	4	3	4	3	4	3	4	3
Task Performance 4	4	3	4	3	4	3	4	3	4	3
Task Performance 5	4	3	4	3	4	3	4	3	4	3

Content Validity Item Ratings For Added Item

Item	Expert 1		Expert 2		Expert 3		Expert 4		Expert 5	
	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality
Written Item 11	4	3	4	3	4	3	4	3	4	3

Information For Interpreting Item Rating Tables

Question	Alias in the table	Levels			
Is this item Relevant?	Relevance	Not Relevant (1)	Somewhat Relevant (2)	Quite Relevant (3)	Very Relevant (4)
Is this item essential to the domain?	Essentiality	Not Necessary (1)	Useful, but not essential (2)	Essential (3)	

F. Content Validity Item Ratings For Post-course Achievement Test

Content Validity Item Ratings For Original Item Pool

Item	Expert 1		Expert 2		Expert 3		Expert 4		Expert 5	
	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality
Written Item 1	2	1	3	2	3	2	3	2	3	2
Written Item 2	3	3	4	3	4	3	4	3	4	3
Written Item 3	3	3	4	3	3	3	3	3	4	3
Written Item 4	4	3	4	3	4	3	4	3	4	3
Written Item 5	4	3	4	3	4	3	4	3	4	3
Written Item 6	4	3	4	3	4	3	4	3	4	3
Written Item 7	3	3	4	3	3	3	4	3	3	3
Written Item 8	4	3	4	3	4	3	4	3	4	3
Written Item 9	4	3	4	3	4	3	4	3	4	3
Written Item 10	3	3	4	3	4	3	4	3	4	3
Task Performance 1	4	3	4	3	4	3	4	3	4	3
Task Performance 2	3	3	3	3	4	3	4	3	3	3
Task Performance 3	4	3	4	3	4	3	4	3	4	3
Task Performance 4	4	3	4	3	4	3	4	3	4	3
Task Performance 5	4	3	4	3	4	3	4	3	4	3

Content Validity Item Ratings For Added Item

Item	Expert 1		Expert 2		Expert 3		Expert 4		Expert 5	
	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality	Relevance	Essentiality
Written Item 11	3	3	4	3	4	3	4	3	4	3

Information For Interpreting Item Rating Tables

Question	Alias in the table	Levels			
Is this item Relevant?	Relevance	Not Relevant (1)	Somewhat Relevant (2)	Quite Relevant (3)	Very Relevant (4)
Is this item essential to the domain?	Essentiality	Not Necessary (1)	Useful, but not essential (2)	Essential (3)	

G. The New World Level 1 Reaction Sheet

Eğitim Sonrası Değerlendirme Formu: General Solid Rivet Application – TTC1998

No	Kategori	Soru	Kesinlikle Katılmıyorum (1)	Katılmıyorum (2)	Katılıyorum (3)	Kesinlikle Katılıyorum (4)
1	Eğitim Hedefleri	Dersin kazandırmaya çalıştırdığı hedefleri anladım				
2		Öğrenme hedeflerinin hepsi öğrendiklerimle yakından ilgiliydi				
3		Ders materyali bana doğru şekilde hitap ediyordu				
4	Ders Materyalleri	Ders materyalleri içerisinde aradığımı rahatlıkla buldum				
5		Ders materyallerinin başarılı olmama yardımcı olacağını hissetim				
6	İçerik	Öğrendiklerimi dersten hemen sonra uygulayabilirim				
7	Eğitmenin Bilgi Düzeyi	Eğitmenin konuya olan hakimiyeti öğrenmemi kolaylaştırdı				
8		Eğitmen tarafından paylaşılan tecrübeler öğrenmemi kolaylaştırdı				
9	Eğitmenin Ders Anlatımı	Dersten hiç kopmadım				
10		Ders boyunca rahatlıkla katılım gösterebildim				
11		Dersin ilerleme hızı bana uygundu				
12		Dersin süresi bence uygundu				
13	Eğitmenin Tarzı	Sorularıma yeterince yanıt alabildim				
14		Öğrenmem gereken becerileri denemek için yeterince fırsat verildi				
15	Değerlendirme	Bildiklerimi göstermek için yeterince fırsat verildi				
16		Becerilerimi göstermek için yeterince fırsat verildi				
17	Ders Araları	Ders aralarından sonra tazelenmiş hissettim				
18	Eğitim Ortamı	Eğitim sınıfının rahat bir ortamı vardı				
19		Eğitim sınıfının yerleşimi iyiydi				
20		Ders süresince dikkatim fazla dağılmadı				

H. The Content-Performance Matrix Interpretation For The Study

The following is the interpretation of Clark's (2011) content-performance matrix for the purposes of the present study. Since the matrix is notably large, it is presented as five pieces each of which corresponds to the suggestions for a particular content type.

CONTENT TYPE	**FACT**
DESCRIPTION & EXAMPLE	Unique, one of a type information
	A specific document A particular number A definition statement
LEARNING OUTCOME	Do not write outcomes directly addressing facts as it puts emphasis on memorization. Instead, write outcomes for tasks which requires the use of factual information
INFORMATION DISPLAYS	Diagram with descriptive text callout
	Table
	List
PRACTICE EXERCISES	Inductive - Keep factual info at sight, ask a question, answer of which can be inferred from shown info
	Incorporate the factual info within a procedural or process task and provide a job aid
	Use a reference-based training model. Address the references for factual info and explain how to access the reference
	Provide mnemonics when available
	Instructor

DELIVERY MEDIA	Job Aid
	Presentation Slides
EVALUATION	Do not address the repeating of factual information. Instead, require authentic job tasks that require the use of factual information
	Write test items or scenarios that require the use of a job aid

CONTENT TYPE	**CONCEPT**
DESCRIPTION & EXAMPLE	Mental representation or prototype of objects/ideas that have multiple specific examples
	A general class with many instances
	Solid Rivet Aluminium Alloy Rivet Gun Project Specification Document
LEARNING OUTCOME	Typically concept outcomes are secondary to a procedural one as its supportive information in nature
	Write your concept outcome at the application level by using an action verb that involves a classification activity
INFORMATION DISPLAYS	A diagram, table, or illustration that has the definition and features of the concept along with examples of it
	Present non-examples in the display as well when available
	Use analogies to depict/explain concepts but beware of the risk as an inappropriate analogy is worse than no analogy

<table>
<tr><td rowspan="1"></td><td>The definition can be shown as bullets dedicated to critical features of the concept</td></tr>
<tr><td rowspan="3">PRACTICE EXERCISES</td><td>Administer a classification task that involves examples and non-examples of the concept which were not used in the course before</td></tr>
<tr><td>Have the trainee perform the identification task when available</td></tr>
<tr><td>If it is impractical to use real objects to discriminate, use paper-pen examples to identify examples of the concept among non-examples</td></tr>
<tr><td rowspan="2">DELIVERY MEDIA</td><td>Instructor</td></tr>
<tr><td>Presentation Slides</td></tr>
<tr><td rowspan="3">EVALUATION</td><td>Utilize the same approach in practice exercises without using the same examples used in practice</td></tr>
<tr><td>Have the trainee perform identification of examples</td></tr>
<tr><td>If a performance-based classification is not possible, use multiple-choice items to examine if the trainee can identify the example of the concept</td></tr>
</table>

<table>
<tr><td>CONTENT TYPE</td><td>PROCESS</td></tr>
<tr><td rowspan="2">DESCRIPTION & EXAMPLE</td><td>Explanation of how a system or mechanism work</td></tr>
<tr><td>How rivets help the transfer of loads
How a crack is formed during removal
How assembly process of aerostructures work</td></tr>
<tr><td></td><td>The decision to include a separate outcome for processes depend on how critical the process is for the improvement of performance on a task</td></tr>
</table>

LEARNING OUTCOME	If the process is "nice to know", include the process knowledge in the course but don't hold your trainees responsible for it in the exam
	If the process is "need to know" for the effective completion of a job task, write an outcome to address it
	Avoid writing outcomes that require the trainee to recall and express the stages of the process
	The outcome must require problem-solving based on knowledge of the process and some data provided for the problem
INFORMATION DISPLAYS	Use flowcharts to depict the stages of the process. Be careful about if it is a circular or linear process
	Tables with line numbers can be used to show the chronological order of stages along with an explanation of each stage
	Informatiıon display must also state how the process is linked with the job tasks taught in the course
PRACTICE EXERCISES	Design of practices is optional for process-type contents. If it is a "nice to know" piece, no need for a specific practice
	If the process is substantially important for a job task, problem-solving situations must be created
	Think about what could go wrong in a given job task. Present problems about malfunctioning, non-conformities or customer complaints and ask the trainee to detect the cause of problem based on the knowledge of how things work
DELIVERY MEDIA	Instructor
	Presentation Slides
EVALUATION	Utilize the same approach in practice exercises without using the same problem situations used in practice
	Have the trainee solve a problem based on process knowledge. The problem can be a fictional one and the solution can be provided verbally or in a written format. Also, when it is practical, a problem situation can be recreated physically to be solved by the trainee

CONTENT TYPE	**PRINCIPLE**
DESCRIPTION & EXAMPLE	A cause-and-effect relationship that results in a predictable outcome
	Material and rivet type must be decided based on the code string in order to comply with aerodynamic design and structural analysis of the part
	In order to eliminate the scratching risk, exceeding rivet length must be equal to 1,5 * rivet diameter + material thickness
	Solid rivets must be preferred when both sides of the structural part are physically at reach. Otherwise, blind rivets must be used.
LEARNING OUTCOME	Avoid outcomes expecting articulation of guidelines or principles
	The outcome must ask the trainee to respond to a realistic job scenario by successfully applying the principles or guidelines
	Oftentimes, supporting outcomes can be needed for principle-type content in addition to the main outcome requiring a response to the scenario with principles
	In supporting outcomes, the trainee must be expected to identify appropriate and/or inappropriate application of principles upon observing
INFORMATION DISPLAYS	Videos or series of images to show as a worked example with various contexts
	Videos or series of images to show as a worked non-example with various contexts
PRACTICE EXERCISES	You can prefer to be either instructive or inductive
	Instructive approach: First, state the principles. Then show worked examples and non-examples. Then ask the trainee to identify them by justifying with respect to stated principles (what is applied correctly? / what is applied inappropriately?)

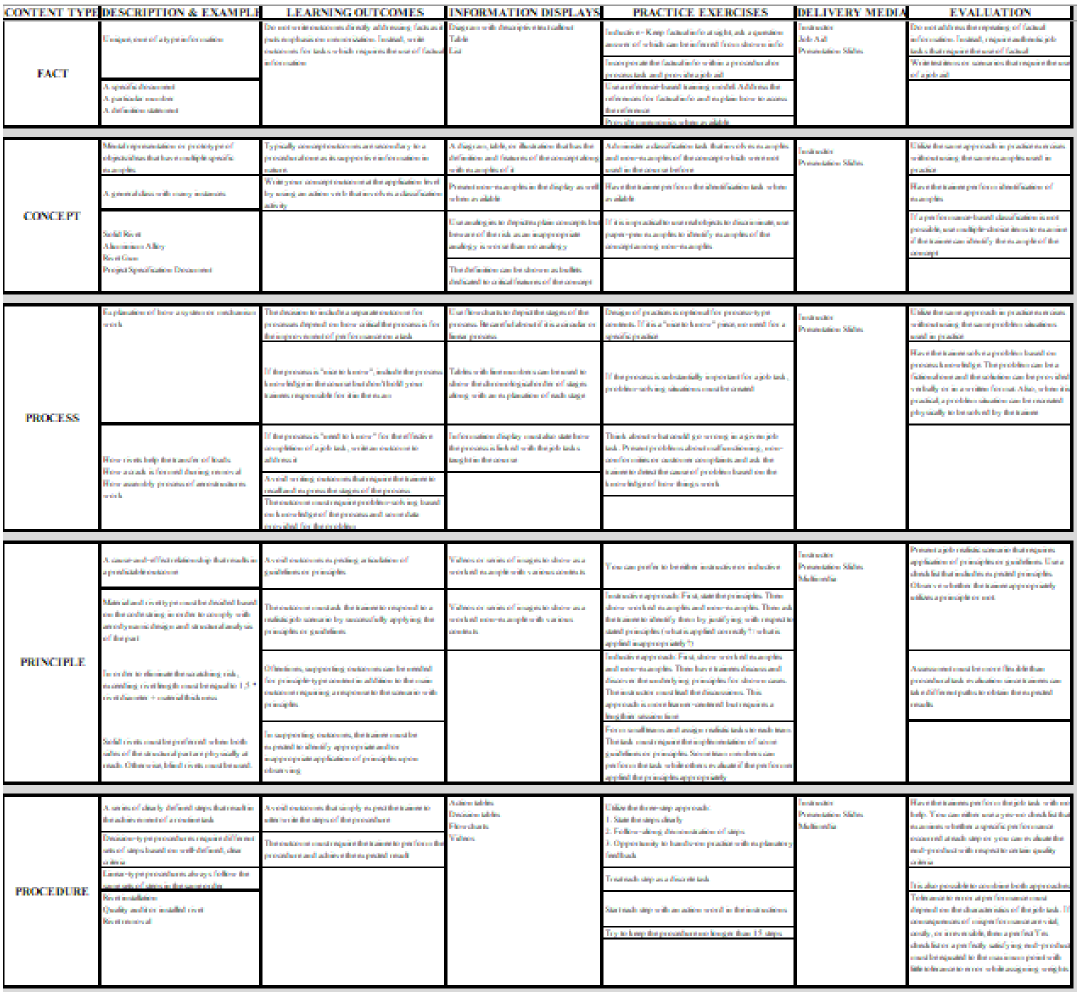
	Inductive approach: First, show worked examples and non-examples. Then have trainees discuss and discover the underlying principles for shown cases. The instructor must lead the discussions. This approach is more learner-centered but requires a lengthier session time
	Form small teams and assign realistic tasks to each team. The task must require the implementation of some guidelines or principles. Some team members can perform the task while others evaluate if the performer applied the principles appropriately
DELIVERY MEDIA	Instructor
	Presentation Slides
	Multimedia
EVALUATION	Present a job realistic scenario that requires application of principles or guidelines. Use a checklist that includes expected principles. Observe whether the trainee appropriately utilizes a principle or not
	Assessment must be more flexible than procedural task evaluation since trainees can take different paths to obtain the expected results

CONTENT TYPE	**PROCEDURE**
DESCRIPTION & EXAMPLE	A series of clearly defined steps that result in the achievement of a routine task
	Decision-type procedures require different sets of steps based on well-defined, clear criteria
	Linear-type procedures always follow the same sets of steps in the same order

	Rivet installation Quality audit or installed rivet Rivet removal
LEARNING OUTCOME	Avoid outcomes that simply expect the trainee to utter/write the steps of the procedure
	The outcome must require the trainee to perform the procedure and achieve the expected result
INFORMATION DISPLAYS	Action Tables
	Decision Tables
	Flowcharts
	Videos
PRACTICE EXERCISES	Utilize the three-step approach: 1. State the steps clearly 2. Follow-along demonstration of steps 3. Opportunity to hands-on practice with explanatory feedback
	Treat each step as a discrete task
	Start each step with an action word in the instructions
	Try to keep the procedure no longer than 15 steps
DELIVERY MEDIA	Instructor
	Presentation Slides
	Multimedia
EVALUATION	Have the trainees perform the job task with no help. You can either use a yes-no checklist that examines whether a specific performance occurred at each step or you can evaluate the end-product with respect to certain quality criteria
	It is also possible to combine both approaches

	Tolerance to error at performance must depend on the characteristics of the job task. If consequences of misperformance are vital, costly, or irreversible, then a perfect Yes checklist or a perfectly satisfying end-product must be equated to the maximum point with little tolerance to error while assigning weights

NOTE: Entire treatment interpretation matrix is too large to show in a single figure as depicted below. Therefore, it can be inspected piece-by-piece for each subtopic.



CONTENT TYPE	DESCRIPTION & EXAMPLE	LEARNING OUTCOMES	INFORMATION DISPLAYS	PRACTICE EXERCISES	DELIVERY MEDIA	EVALUATION
FACT	[illegible]	[illegible]	[illegible] Table List	[illegible]	Instructor Job Aid Presentation Slides	[illegible]
CONCEPT	[illegible]	[illegible]	[illegible]	[illegible]	Instructor Presentation Slides	[illegible]
PROCESS	[illegible]	[illegible]	[illegible]	[illegible]	Instructor Presentation Slides	[illegible]
PRINCIPLE	[illegible]	[illegible]	[illegible]	[illegible]	Instructor Presentation Slides Multimedia	[illegible]
PROCEDURE	[illegible]	[illegible]	Action tables Decision tables Flow charts Videos	[illegible]	Instructor Presentation Slides Multimedia	[illegible]

İ. The Treatment Matrix

The following is the summary of all treatment interventions based upon the Content-Performance Matrix Interpretation For The Study (see Appendix H). Since the matrix is notably large, it is presented as seventeen pieces each of which corresponds to the interventions for a particular subtopic. Text in red color refers to the original situation of a certain aspect of the course whereas the text in green refers to the changes made for treatment purposes.

TOPIC	SOLID RIVET APPLICATION
SUBTOPIC	General Description
ORIGINAL CONTENT	• Fastener definition • Rivet definition • When to use a solid rivet
ASSIGNED CONTENT TYPES	• Fastener (FACT) • Rivet (FACT) • When to use solid rivet (PRINCIPLE)
LEARNING OUTCOMES	*Express the definition of a solid rivet. *Explain the case when using a solid rivet is appropriate.
	*Decide whether it is appropriate to use a solid rivet for a given condition.
INFORMATION DISPLAYS	*Text definitions for fastener and rivet. *Photos of fasteners and rivets.
	*A table with photos and definitions for fasteners and rivets.
	*Instructor asks trainees to recall or take note of rivet definition.

PRACTICE EXERCISES	*No specific practice for definitions. *One exemplary and one non-exemplary condition is described. *Class discussion on examples. Which one is a solid rivet case?
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Written Item with a visual: "When is it inappropriate to use a solid rivet? Circle the correct option(s)."

TOPIC	**SOLID RIVET APPLICATION**
SUBTOPIC	**Specifications**
ORIGINAL CONTENT	• Specifications for different projects
ASSIGNED CONTENT TYPES	• Specifications (CONCEPT)
LEARNING OUTCOMES	*Express what a project specification is *Explain the importance of specifications
	*No learning were outcomes specified since the understanding of specifications is a part of another learning outcome
	*Screenshots of various project specification documents (low readability)

INFORMATION DISPLAYS	*Existing screenshots were preserved. *Callouts inserted on the very first screenshot. Callouts show the functionality of parts of the document (i.e. Project Code, Revision Date, Company, Expiration Date, etc). *An analogy of a cooking receipt was utilized to better explain the role of specifications in operation.
PRACTICE EXERCISES	*No practice exercise
	*2 sets of visuals of a real project specification document and a SOIR document shown side by side. Trainees are asked to identify which one is a specification document (SOIR documents are likely to be confused with specifications during operations)
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**SOLID RIVET APPLICATION**
SUBTOPIC	**Standards**
ORIGINAL CONTENT	• Different standards required by different authorities
ASSIGNED CONTENT TYPES	• Standards (CONCEPT)
	*No target behavior specified

LEARNING OUTCOMES	*No learning outcomes were specified
INFORMATION DISPLAYS	*List of various standards and related authorities
	*Existing lists were preserved.
PRACTICE EXERCISES	*No practice exercise
	*No practice exercise
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**INTRODUCTION TO RIVETS**
SUBTOPIC	**Rivet Types**
ORIGINAL CONTENT	•Two main types of rivets •Subtypes of rivets
ASSIGNED CONTENT TYPES	• Main types (CONCEPT) • Subtypes (CONCEPT)
LEARNING OUTCOMES	*Identify universal solid rivet. *Identify countersink solid rivet.
	*Distinguish between different types of solid rivets.

INFORMATION DISPLAYS	*Textual explanation of the fact that there are many types of solid rivets. *A single table showing how subtypes are categorized under two main types of solid rivets (European, German, US, France standards).
	*Existing table was preserved. *Another table was created with the illustration of two main types along with their characteristic features in the text. *An illustration was created depicting two main solid rivets types side by side with other fasteners like bolts, nuts, hi-locks as non-example vs example.
PRACTICE EXERCISES	*Instructor distributes a pair of real solid rivets to trainees and asks them which one is the main type.
	*Instructor distributes a pair of real solid rivets to trainees and asks them which one is which the main type. *Instructor also distributes real fasteners that are not solid rivets after the first activity. Then trainees are asked to distinguish solid rivets from others.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Written Item with a visual: "Find the solid rivets in the visual. Circle corresponding letter(s)" Performance task: The trainee is required to pick the correct type of solid rivet from the box that is specified in the code string

TOPIC	**INTRODUCTION TO RIVETS**
SUBTOPIC	**Rivet Definition Protocol**

ORIGINAL CONTENT	• Code strings for fastener operations • Rivet materials • Rivet dimensions • Rivet head markings
ASSIGNED CONTENT TYPES	• Code string structure (CONCEPT) • Rivet materials (CONCEPT) • Rivet dimensions (CONCEPT) • Rivet head markings (CONCEPT) • Interpreting a code string to determine the material, dimension, and subtype (PRINCIPLE)
LEARNING OUTCOMES	*No target behavior specified. *Interpret the rivet code strings correctly. *Identify the material of a given solid rivet based on visual cues. *Distinguish between different types of solid rivets.
INFORMATION DISPLAYS	*Four diagrams breaking code strings into subparts with callouts stating what the subpart is about. *Two tables presenting material codes for different standards. *A bullet list that shows material codes for corresponding alloys and the components of the alloy. *Technical drawings of two main type rivets with callouts stating dimensions of certain sections. *A table listing dimensions for different rivet diameters. *A list showing different head markings and their corresponding materials and rivet types. *All existing displays were preserved as they are well-aligned with Clark's (2011) suggestions for concept-type content.
PRACTICE EXERCISES	*Instructor shows a code string on the slide and asks the class to interpret it. (Activity is repeated twice) *Instructor interprets two code strings for two different standards and highlights how he understands if the initial part of string refers to a part or a standard. *Instructor distributes real solid rivets and asks random trainees to identify the material and type of the rivet based on visual cues. *Instructor distributes a worksheet including three code strings and asks trainees to pick correct rivets for each string.
	Instructor, Presentation File

DELIVERY MEDIA	Instructor, Presentation File
EVALUATION	Written Item with a visual: "Find the solid rivets in the visual. Circle corresponding letter(s)" Written Item with a visual: "Write the correct rivet code for head markings shown in the figure." Performance task: The trainee is required to pick the correct type of solid rivet from the box that is specified in the code string

TOPIC	**INTRODUCTION TO RIVETS**
SUBTOPIC	**Rivets On Technical Drawings**
ORIGINAL CONTENT	• Representation of solid rivets in technical drawings
ASSIGNED CONTENT TYPES	• Symbols for rivets (FACT) • Symbols for operational instructions (FACT)
LEARNING OUTCOMES	*No target behavior specified.
	*No learning outcomes were specified. (There is a separate course covering technical drawing reading and it is generally taken before this course.)
INFORMATION DISPLAYS	*Table of visual symbols along with corresponding rivet types and their features. *Table of visual symbols along with corresponding operational instructions.
	*All existing displays were preserved as they are well-aligned with Clark's (2011) suggestions for concept-type content.

PRACTICE EXERCISES	*No practice exercise.
	*Instructor shows two technical drawings depicting very common types of operations and then asks random trainees to interpret them. The instructor provides explanatory feedback. (Activity is included to make an opportunity to check technical drawing reading skills. If trainees, in general, seem lacking the skills, interpretation examples are repeated with different examples)
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**SPECIAL CONDITIONS OF USE**
SUBTOPIC	**Heat Work**
ORIGINAL CONTENT	• When to conduct heat work •Constraints on rivet heat work
ASSIGNED CONTENT TYPES	• When to conduct heat work (PRINCIPLE) •Constraints on rivet heat work (FACT)
LEARNING OUTCOMES	*No target behavior specified.
	*No learning outcomes were specified. (Heat work is an optional and uncommon treatment in rivets)
INFORMATION DISPLAYS	*Textual explanation of when to use heat work with rivets. *Textual explanation of conditions for use of heat work with rivets.
	*Flowchart depicting the decision mechanism for using heat work with rivets.
	*No practice exercise

PRACTICE EXERCISES	*Instructor shows two code strings and asks trainees to decide if heat work can be applied to these situations. (One exemplary, one non-exemplary string).
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**RIVET INSTALLATION PROCEDURE**
SUBTOPIC	**Spacing and Distances**
ORIGINAL CONTENT	• Rivet spacing • Edge distance • Engineering Minimum
ASSIGNED CONTENT TYPES	• Rivet spacing (CONCEPT) • Edge distance (CONCEPT) • Engineering Minimum (PRINCIPLE)
LEARNING OUTCOMES	*No target behavior specified.
	*No learning outcomes were specified. (There is a separate course covering geometric placement and tolerancing and it is generally taken before this course.)
INFORMATION DISPLAYS	*Textual explanation for rivet spacing. *Textual explanation for edge distancing. *Textual definition of engineering minimum and its importance. *Visual representations of rivet spacing and edge distancing on technical illustrations with callouts to respective terms. *Three tables for three different specifications that show rivet spacing, edge distance, and engineering minimum values for each rivet type.
	*Existing technical illustration with callout was preserved. *Two additional technical illustrations dedicated to each concept were also created to let trainees see them independently. *Tables of dimensions for different rivet types in different specifications were preserved.

	*An illustration summarizing steps to read and decide dimensions for a specific rivet type was created as a worked example. On that visual, checking the engineering minimum value is emphasized.
PRACTICE EXERCISES	*No practice exercise
	*Instructor shows two different technical illustrations with two highlighted spots. Then, trainees are asked to determine which spot is rivet spacing and which spot is edge distance. *Instructor shows a dimension table along with a code string and asks trainees to interpret the string to find the rivet type and then determine correct dimensions for found string type. *Instructor intervenes in the previous activity when engineering minimum is not checked to remind the importance of checking; if engineering minimum is checked, the instructor still intervenes to emphasize the correct decision.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Written Item with a table: "Use the table below to determine rivet spacing and edge distance values for NAS-1097-AD-5-0 in the KUH project."

TOPIC	**RIVET INSTALLATION PROCEDURE**
SUBTOPIC	**Hole Diameters**
ORIGINAL CONTENT	• Hole diameter • Tool selection • Reading diameter tables
ASSIGNED CONTENT TYPES	• Hole diameter (CONCEPT) • Tool selection (PRINCIPLE) • Reading diameter tables (PROCEDURE)
LEARNING OUTCOMES	*Express the hole diameter principles correctly.
	*Determine the hole diameter for any given solid rivet.

INFORMATION DISPLAYS	*Technical illustration depicting the hole diameter on an installed rivet. *Textual explanation for what tool is appropriate under what circumstances. *Illustrations of two drilling tools with their names on them. *Seven different diameter tables for seven different projects.
	*Technical illustration depicting the hole diameter on installed rivet was preserved but callouts for important spots were added on it. *A table that shows two drilling tools along with a bullet list for each where bullet lists summarize when to use the tool. *Diameter tables for different projects were preserved. *Highlighting animations with step numbers were added on the most commonly used diameter table to show a step-by-step reading of the table.
PRACTICE EXERCISES	*Instructor asks trainees to recall and repeat back the principles to select a correct drilling tool.
	*Instructor shows two illustrations; first with a well-fit hole diameter and a second one with a misfit. Then, trainees are asked to identify the correct hole diameter fit. *Instructor poses two scenarios with different requirements and physical situations. Then asks trainees to justify their decision under those circumstances: (Which drilling tool should be used? Oversizing? Dimpling? Tool-oversize-dimpling combination and its justification) *Instructor conducts a follow-along demonstration on how to read the diameter table. Then, asks random trainees to read a shown table by including a different trainee for each different step of the reading procedure.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Written Item with visual: "Review the visuals. Circle your answer if the diagram correctly represents the drawing." Performance task: The trainee is required to check whether hole diameter is appropriate for given rivet installation.

TOPIC	**RIVET INSTALLATION PROCEDURE**
SUBTOPIC	**Rivet Length**
ORIGINAL CONTENT	• How to calculate rivet length
ASSIGNED CONTENT TYPES	• How to calculate rivet length (PROCEDURE)
LEARNING OUTCOMES	*Calculate the rivet length correctly.
	*Install the solid rivet by satisfying exceeding length and gap criteria
INFORMATION DISPLAYS	*Textual explanation of the formula for rivet length calculation. *Technical illustration depicting the spots mentioned in the calculation formula. *Bullet list showing the different values of coefficient in the calculation formula for different types of materials. *Mathematical statements of formulas for two main types of solid rivets.
	*Technical illustration depicting the spots mentioned in the calculation formula was preserved. *Mathematical statements of formulas for two main types of solid rivets were preserved. *A decision table was created. The decision table provides a walkthrough for the rivet calculation procedure by specifying the required action or decision at each row. Based on the decision, different actions are followed. The decision table leads the trainee to calculate the correct rivet length based on the material and rivet type.
PRACTICE EXERCISES	*Instructor presents a scenario where a material and rivet type is specified for a particular project. Then, trainees are asked to lead the instructor to calculate the correct rivet length.
	*Instructor conducts a follow-along demonstration and calculates rivet lengths once for each of two main rivet types. *Instructor asks trainees to calculate the correct rivet length on their own for a given technical drawing and code string.

	*Instructor asks trainees to install rivets according to given code string and technical drawing.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Written Item: "What is the correct rivet length for a countersink on monel material in terms of D?" Written Item: "What rivet length must be used for MS-20470-AD-4-10?" Performance task: The trainee is required to install the rivet so that exceeding length and gaps satisfy the specification for the material and type of used rivet

TOPIC	**RIVET INSTALLATION PROCEDURE**
SUBTOPIC	**Equipment And Tools**
ORIGINAL CONTENT	• Introduction of tools used in rivetting
ASSIGNED CONTENT TYPES	• Tools used in rivetting (CONCEPT)
LEARNING OUTCOMES	*No target behavior specified.
	*No learning outcomes were specified. (There is a separate course covering features and applications of tools)
	*Textual information for four different tools. *Illustrations of four different tools and their leads. *Two tables for selecting subtypes of tools or selection of leads.

INFORMATION DISPLAYS	*A table showing four main tools with their names, illustrations, and main features as bullets in three columns. *Two tables for selecting subtypes or leads.
PRACTICE EXERCISES	*No practice exercise
	*Instructor asks random trainees to collect a certain tool from the workbench and pick the appropriate lead for it specified by the instructor
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**RIVET INSTALLATION PROCEDURE**
SUBTOPIC	**Hole Preparation**
ORIGINAL CONTENT	• Preliminaries • Marking • Use of drill block • Use of drill gun • Deburring
ASSIGNED CONTENT TYPES	• Preliminaries (FACT) • Marking (PROCEDURE) • Use of drill block (PROCEDURE) • Use of drill gun (PROCEDURE) • Deburring (PROCEDURE)
LEARNING OUTCOMES	*Express three main stages of hole preparation.
	*Install the solid rivet by satisfying exceeding length and gap criteria
INFORMATION DISPLAYS	*Textual explanation of preliminary conditions before starting hole preparation. *Textual explanation of hole preparation procedure. *Textual information on warnings and critical issues in hole preparation.

	*Illustrations showing correct and incorrect holding position for drill gun.
	*A bullet list of preliminary conditions. *Action table for hole preparation procedure with representative figures for each main step. *A bullet list of warnings and critical issues paired with three main stages of hole preparation. *Illustrations showing correct and incorrect holding positions for drill gun were preserved.
PRACTICE EXERCISES	*Instructor conducts a follow-along demonstration of hole preparation. *Instructor forms small teams of four trainees and distributes code strings and technical drawings for each team. Then, each team member is required to conduct the hole preparation on his own.
	*Existing practice activities were preserved. The only difference is that the instructor and senior trainees picked by the instructor are asked to provide explanatory feedback during the practice.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Written Item: "Calculate the acceptable exceeding length after installation for NASM-20426-AD4-12A-5? (Take material thickness = 10 mm)" Performance task: The trainee is required to conduct hole preparation during rivet installation. The trainee is expected to do marking, use drill block, hold drill gun in the correct position and make deburring in this exact chronological order.

TOPIC	**RIVET INSTALLATION PROCEDURE**
SUBTOPIC	**Countersinking**
ORIGINAL CONTENT	• When to use countersinking • How to countersink

ASSIGNED CONTENT TYPES	• When to use countersinking (PROCEDURE) • How to countersink (PROCEDURE)
LEARNING OUTCOMES	*No target behavior specified.
	*No learning outcomes specified (Countersinking is an optional and minor part of hole preparation which is also a partial component of a significant and meaningful procedure as well)
INFORMATION DISPLAYS	*Textual explanation of when to use countersinking *Illustrations showing situations when countersinking is needed on the part. *Textual description of the countersinking procedure.
	*A decision table explaining when and how to conduct countersinking. *Illustrations showing situations when countersinking is needed on the part.
PRACTICE EXERCISES	*Instructor conducts a follow-along demonstration of countersinking. *Instructor forms small teams of four trainees and distributes code strings and technical drawings for each team. Then, each team member is required to conduct the countersinking on his own.
	*Existing practice activities were preserved. The only difference is that the instructor and senior trainees picked by the instructor are asked to provide explanatory feedback during the practice.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**RIVET INSTALLATION PROCEDURE**
SUBTOPIC	**Critical Warnings**

ORIGINAL CONTENT	• Summary
ASSIGNED CONTENT TYPES	• Summary of the content covered up to that point (MISCELLANEOUS)
LEARNING OUTCOMES	N/A
	N/A
INFORMATION DISPLAYS	*Textual statements regarding warnings, critical issues, important points. *Illustrations showing common mistakes.
	*Separate bullet lists were created for warning and critical issues. *Illustrations showing common mistakes were preserved.
PRACTICE EXERCISES	*No practice exercise
	*Instructor asks trainees to recall and express what they remember about certain bullet points.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**QUALITY CONTROL**
SUBTOPIC	**Audit Criteria**
ORIGINAL CONTENT	• General criteria • Project-based criteria

ASSIGNED CONTENT TYPES	• General criteria (PRINCIPLE) • Project-based criteria (PRINCIPLE)
LEARNING OUTCOMES	*Express general criteria. *Control his own work.
	*Audit an installed solid rivet to understand whether it is non-conforming for a given specification
INFORMATION DISPLAYS	*Bullet list of general criteria. *Bullet lists of specific criteria for several projects *Technical illustrations showing non-conforming situations.
	*Bullet list of general criteria was preserved. This information is also distributed as a reference sheet. *Bullet lists of specific criteria were preserved with the addition of how to access these lists through company systems.
PRACTICE EXERCISES	*Instructor asks trainees to evaluate the rivets they installed in the workshop and decide if there are any non-conformities.
	*Instructor asks trainees to evaluate the rivets they installed in the workshop and decide if there are any non-conformities. *Instructor also presents a series of installed rivets which represent common non-conformities and asks trainees to audit them and share their conclusions. Then a class discussion starts regarding if the audit conclusion is valid or not.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Performance task: The trainee is required to audit the rivet he installed earlier. The trainee is expected to check exceeding length, rivet height, back & front gaps by measuring through an appropriate too. Then, the trainee is required to provide a valid conclusion based on his audit.

TOPIC	**QUALITY CONTROL**
SUBTOPIC	**Trimming**

ORIGINAL CONTENT	• When to use trimming • How to trim • Untrimmable rivets
ASSIGNED CONTENT TYPES	• When to use trimming (PROCEDURE) • How to trim (PROCEDURE) • Untrimmable rivets (FACT)
LEARNING OUTCOMES	*No target behavior specified
	*No learning outcomes were specified
INFORMATION DISPLAYS	*Bullet list explanation for when to trim *Bullet list explanation for how to trim *Textual information on untrimmable rivets
	*A decision table explaining when and how to conduct trimming. *A table showing illustrations of untrimmable rivets along with their names and codes.
PRACTICE EXERCISES	*No practice exercise
	*No practice exercise (Trimming is a special operation that is limited to a certain type of personnel with particular training and experience. Therefore, this course does not aim to teach trimming. Instead, it is aimed to provide rivet installers with a general knowledge of the phenomenon)
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	No items particularly address this content piece

TOPIC	**QUALITY CONTROL**
SUBTOPIC	**Removal of Non-Conforming Installations**
ORIGINAL CONTENT	• Lead and drill gun selection • How to remove installed rivet

ASSIGNED CONTENT TYPES	• Lead and drill gun selection (PROCEDURE) • How to remove installed rivet (PROCEDURE)
LEARNING OUTCOMES	*Remove rivet without harming the structural part
	*Remove a non-conforming solid rivet without causing cracks or scratches to the structural part
INFORMATION DISPLAYS	*Bullet list explanation for how to remove installed rivet *Illustrations showing four stages of rivet removal *A table showing appropriate lead and drill gun options for different rivet diameters
	*A decision table explaining how to conduct rivet removal featuring illustrations of four stages of removal. *A table showing appropriate lead and drill gun options for different rivet diameters was preserved.
PRACTICE EXERCISES	*Instructor conducts a follow-along demonstration of rivet removal.
	*Existing practice activity was preserved. *Instructor asks trainees to remove the rivets they installed for previous activities and provide them with explanatory feedback.
DELIVERY MEDIA	Instructor, Presentation File
	Instructor, Presentation File
EVALUATION	Written Item with visual: "Inspect the visual carefully. Is the holding position for the drill gun is appropriate? (Circle your answer)" Performance task: The trainee is required to remove the rivet he installed earlier. The trainee is expected to finish the operation without leaving any crack or scratch on the structural part. The trainee is also required to use an appropriate lead and drill gun.

NOTE: Entire treatment matrix is too large to show in a single figure as depicted below. Therefore, it can be inspected piece-by-piece for each subtopic.

TOPIC	SUBTOPIC	ORIGINAL CONTENT	TREATMENT - ASSIGNED CONTENT TYPES	TREATMENT - LEARNING OUTCOMES	TREATMENT - INSTRUCTIONAL METHODS		TREATMENT - DELIVERY MEDIA	EVALUATION
					INFORMATION DISPLAYS	PRACTICE EXERCISES		
Solid Rivet Application	General description	•Fastener definition •Rivet definition •When to a use solid rivet	•Fastener (FACT) •Rivet (FACT) •When to use solid rivet (PRINCIPLE)	*Express the definition of a solid rivet. *Explain the case when using a solid rivet is appropriate. *Decide whether it is appropriate to use a solid rivet for a given condition	*Text definitions for fastener and rivet. *Photos of fasteners and rivets. *A table with photos and definitions for fasteners and rivets.	*Instructor asks trainees to recall or take note of rivet definition. *No specific practice for definitions. *One exemplary and one non-exemplary condition is described. *Class discussion on examples. Which one is a solid rivet case?	Instructor, Presentation File Instructor, Presentation File	Written Item with a visual: "When is it inappropriate to use a solid rivet? Circle the correct option(s)."
	Specifications	•Specifications for different projects	•Specifications (CONCEPT)	*Express what a project specification is *Explain the importance of specifications *No learning outcomes specified since the understanding of specifications is a part of another learning outcome	*Screenshots of various project specification documents (low readability) *Existing screenshots were preserved. *Callouts inserted on the very first screenshot. Callouts show the functionality of parts of the document (i.e. Project Code, Revision Date, Company, Expiration Date, etc). *An analogy of a cooking receipt was utilized to better explain the role of specifications in operation.	*No practice exercise *2 sets of visuals of a real project specification document and a SOIR document shown side by side. Trainees are asked to identify which one is a specification document (SOIR documents are likely to be confused with specifications during operations)	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
	Standards	•Different standards required by different authorities	•Standards (CONCEPT)	*No target behavior specified *No learning outcomes were specified	*List of various standards and related authorities *Existing lists were preserved.	*No practice exercise *No practice exercise	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
Introduction to Rivets	Rivet types	•Two main types of rivets •Subtypes of rivets	•Main types (CONCEPT) •Subtypes (CONCEPT)	*Identify universal solid rivet. *Identify countersink solid rivet. *Distinguish between different types of solid rivets.	*Textual explanation of the fact that there are many types of solid rivets. *A single table showing how subtypes are categorized under two main types of solid rivets (European, German, US, France standards). *Existing table was preserved. *Another table was created with the illustration of two main types along with their characteristic features in the text. *An illustration was created depicting two main solid rivets types side by side with other fasteners like bolts, nuts, hi-locks as non-example vs example.	*Instructor distributes a pair of real solid rivets to trainees and asks them which one is the main type. *Instructor distributes a pair of real solid rivets to trainees and asks them which one is which the main type. *Instructor also distributes real fasteners that are not solid rivets after the first activity. Then trainees are asked to distinguish solid rivets from others.	Instructor, Presentation File Instructor, Presentation File	Written Item with a visual: "Find the solid rivets in the visual. Circle corresponding letter(s)" Performance task: The trainee is required to pick the correct type of solid rivet from the box that is specified in the code string
	Rivet definition protocol	• Code strings for fastener operations • Rivet materials • Rivet dimensions • Rivet head markings	• Code string structure (CONCEPT) • Rivet materials (CONCEPT) • Rivet dimensions (CONCEPT) • Rivet head markings (CONCEPT) • Interpreting a code string to determine the material, dimension, and subtype (PRINCIPLE)	*No target behavior specified. *Interpret the rivet code strings correctly. *Identify the material of a given solid rivet based on visual cues. *Distinguish between different types of solid rivets.	*Four diagrams breaking code strings into subparts with callouts stating what the subpart is about. *Two tables presenting material codes for different standards. *A bullet list that shows material codes for corresponding alloys and the components of the alloy. *Technical drawings of two main type rivets with callouts stating dimensions of certain sections. *A table listing dimensions for different rivet diameters. *A list showing different head markings and their corresponding materials and rivet types. *All existing displays were preserved as they are well-aligned with Clark's (2011) suggestions for concept-type content.	*Instructor shows a code string on the slide and asks the class to interpret it. (Activity is repeated twice) *Instructor interprets two code strings for two different standards and highlights how he understands if the initial part of string refers to a part or a standard. *Instructor distributes real solid rivets and asks random trainees to identify the material and type of the rivet based on visual cues. *Instructor distributes a worksheet including three code strings and asks trainees to pick correct rivets for each string.	Instructor, Presentation File Instructor, Presentation File	Written Item with a visual: "Find the solid rivets in the visual. Circle corresponding letter(s)" Written Item with a visual: "Write the correct rivet code for head markings shown in the figure." Performance task: The trainee is required to pick the correct type of solid rivet from the box that is specified in the code string
	Rivets on technical drawings	• Representation of solid rivets in technical drawings	•Symbols for rivets (FACT) •Symbols for operational instructions (FACT)	*No target behavior specified. *No learning outcomes were specified. (There is a separate course covering technical drawing reading and it is generally taken before this course.)	*Table of visual symbols along with corresponding rivet types and their features. *Table of visual symbols along with corresponding operational instructions. *All existing displays were preserved as they are well-aligned with Clark's (2011) suggestions for concept-type content.	*No practice exercise. *Instructor shows two technical drawings depicting very common types of operations and then asks random trainees to interpret them. The instructor provides explanatory feedback. (Activity is included to make an opportunity to check technical drawing reading skills. If trainees, in general, seem lacking the skills, interpretation examples are repeated with different examples)	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
Special Conditions of Use	Heat Work	•When to conduct heat work •Constraints on rivet heat work	•When to conduct heat work (PRINCIPLE) •Constraints on rivet heat work (FACT)	*No target behavior specified. No learning outcomes were specified. (Heat work is an optional and uncommon treatment in rivets)	*Textual explanation of when to use heat work with rivets. *Textual explanation of conditions for use of heat work with rivets. *Flowchart depicting the decision mechanism for using heat work with rivets.	*No practice exercise *Instructor shows two code strings and asks trainees to decide if heat work can be applied to these situations. (One exemplary, one non-exemplary string).	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
Rivet Installation Procedure	Spacing and distances	• Rivet spacing • Edge distance • Engineering Minimum	• Rivet spacing (CONCEPT) • Edge distance (CONCEPT) • Engineering Minimum (PRINCIPLE)	*No target behavior specified. *No learning outcomes were specified. (There is a separate course covering geometric placement and tolerancing and it is generally taken before this course.)	*Textual explanation for rivet spacing. *Textual explanation for edge distancing. *Textual definition of engineering minimum and its importance. *Visual representations of rivet spacing and edge distancing on technical illustrations with callouts to respective terms. *Three tables for three different specifications that show rivet spacing, edge distance, and engineering minimum values for each rivet type. *Existing technical illustration with callout was preserved. *Two additional technical illustrations dedicated to each concept were also created to let trainees see them independently. *Tables of dimensions for different rivet types in different specifications were preserved. *An illustration summarizing steps to read and decide dimensions for a specific rivet type was created as a worked example. On that visual, checking the engineering minimum value is emphasized.	*No practice exercise *Instructor shows two different technical illustrations with two highlighted spots. Then, trainees are asked to determine which spot is rivet spacing and which spot is edge distance. *Instructor shows a dimension table along with a code string and asks trainees to interpret the string to find the rivet type and then determine correct dimensions for found string type. *Instructor intervenes in the previous activity when engineering minimum is not checked to remind the importance of checking; if engineering minimum is checked, the instructor still intervenes to emphasize the correct decision.	Instructor, Presentation File Instructor, Presentation File	Written Item with a table: "Use the table below to determine rivet spacing and edge distance values for NAS-1097-AD-5-0 in the KUH project."
	Hole diameters	• Hole diameter • Tool selection • Reading diameter tables	• Hole diameter (CONCEPT) • Tool selection (PRINCIPLE) • Reading diameter tables (PROCEDURE)	*Express the hole diameter principles correctly. *Determine the hole diameter for any given solid rivet.	*Technical illustration depicting the hole diameter on an installed rivet. *Textual explanation for what tool is appropriate under what circumstances. *Illustrations of two drilling tools with their names on them. *Seven different diameter tables for seven different projects. *Technical illustration depicting the hole diameter on installed rivet was preserved but callouts for important spots were added on it. *A table that shows two drilling tools along with a bullet list for each where bullet lists summarize when to use the tool. *Diameter tables for different projects were preserved. *Highlighting animations with step numbers were added on the most commonly used diameter table to show a step-by-step reading of the table.	*Instructor asks trainees to recall and repeat back the principles to select a correct drilling tool. *Instructor shows two illustrations; first with a well-fit hole diameter and a second one with a misfit. Then, trainees are asked to identify the correct hole diameter fit. *Instructor poses two scenarios with different requirements and physical situations. Then asks trainees to justify their decision under those circumstances: (Which drilling tool should be used? Oversizing? Dimpling? Tool-oversize-dimpling combination and its justification) *Instructor conducts a follow-along demonstration on how to read the diameter table. Then, asks random trainees to read a shown table by including a different trainee for each different step of the reading procedure.	Instructor, Presentation File Instructor, Presentation File	Written Item with visual: "Review the visuals. Circle your answer if the diagram correctly represents the drawing." Performance task: The trainee is required to check whether hole diameter is appropriate for given rivet installation.
	Rivet length	• How to calculate rivet length	• How to calculate rivet length (PROCEDURE)	*Calculate the rivet length correctly. *Install the solid rivet by satisfying exceeding length and gap criteria	*Textual explanation of the formula for rivet length calculation. *Technical illustration depicting the spots mentioned in the calculation formula. *Bullet list showing the different values of coefficient in the calculation formula for different types of materials. *Mathematical statements of formulas for two main types of solid rivets.*Technical illustration depicting the spots mentioned in the calculation formula was preserved. *Mathematical statements of formulas for two main types of solid rivets were preserved. *A decision table was created. The decision table provides a walkthrough for the rivet calculation procedure by specifying the required action or decision at each row. Based on the decision, different actions are followed. The decision table leads the trainee to calculate the correct rivet length based on the material and rivet type.	*Instructor presents a scenario where a material and rivet type is specified for a particular project. Then, trainees are asked to lead the instructor to calculate the correct rivet length. *Instructor conducts a follow-along demonstration and calculates rivet lengths once for each of two main rivet types. *Instructor asks trainees to calculate the correct rivet length on their own for a given technical drawing and code string. *Instructor asks trainees to install rivets according to given code string and technical drawing.	Instructor, Presentation File Instructor, Presentation File	Written Item: "What is the correct rivet length for a countersink on monel material in terms of D?" Written Item: "What rivet length must be used for MS-20470-AD-4-10?" Performance task: The trainee is required to install the rivet so that exceeding length and gaps satisfy the specification for the material and type of used rivet
	Equipment and tools	• Introduction of tools used in rivetting	• Tools used in rivetting (CONCEPT)	*No target behavior specified. *No learning outcomes were specified. (There is a separate course covering features and applications of tools)	*Textual information for four different tools. *Illustrations of four different tools and their leads. *Two tables for selecting subtypes of tools or selection of leads. *A table showing four main tools with their names, illustrations, and main features as bullets in three columns. *Two tables for selecting subtypes or leads.	*No practice exercise *Instructor asks random trainees to collect a certain tool from the workbench and pick the appropriate lead for it specified by the instructor	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
	Hole preparation	• Preliminaries • Marking • Use of drill block • Use of drill gun • Deburring	• Preliminaries (FACT) • Marking (PROCEDURE) • Use of drill block (PROCEDURE) • Use of drill gun (PROCEDURE) • Deburring (PROCEDURE)	*Express three main stages of hole preparation. *Install the solid rivet by satisfying exceeding length and gap criteria	*Textual explanation of preliminary conditions before starting hole preparation. *Textual explanation of hole preparation procedure. *Textual information on warnings and critical issues in hole preparation. *Illustrations showing correct and incorrect holding position for drill gun. *A bullet list of preliminary conditions. *Action table for hole preparation procedure with representative figures for each main step. *A bullet list of warnings and critical issues paired with three main stages of hole preparation. *Illustrations showing correct and incorrect holding positions for drill gun were preserved.	*Instructor conducts a follow-along demonstration of hole preparation. *Instructor forms small teams of four trainees and distributes code strings and technical drawings for each team. Then, each team member is required to conduct the hole preparation on his own. *Existing practice activities were preserved. The only difference is that the instructor and senior trainees picked by the instructor are asked to provide explanatory feedback during the practice.	Instructor, Presentation File Instructor, Presentation File	Written Item: "Calculate the acceptable exceeding length after installation for NASM-20426-AD4-12A-5? (Take material thickness = 10 mm)" Performance task: The trainee is required to conduct hole preparation during rivet installation. The trainee is expected to do marking, use drill block, hold drill gun in the correct position and make deburring in this exact chronological order.
	Countersinking	• When to use countersinking • How to countersink	• When to use countersinking (PROCEDURE) • How to countersink (PROCEDURE)	*No target behavior specified. *No learning outcomes specified (Countersinking is an optional and minor part of hole preparation which is also a partial component of a significant and meaningful procedure as well)	*Textual explanation of when to use countersinking *Illustrations showing situations when countersinking is needed on the part. *Textual description of the countersinking procedure. *A decision table explaining when and how to conduct countersinking. *Illustrations showing situations when countersinking is needed on the part.	*Instructor conducts a follow-along demonstration of countersinking. *Instructor forms small teams of four trainees and distributes code strings and technical drawings for each team. Then, each team member is required to conduct the countersinking on his own. *Existing practice activities were preserved. The only difference is that the instructor and senior trainees picked by the instructor are asked to provide explanatory feedback during the practice.	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
	Critical warnings	• Summary	• Summary of the content covered up to that point (MISCELLANEOUS)	N/A	*Textual statements regarding warnings, critical issues, important points. *Illustrations showing common mistakes. *Separate bullet lists were created for warning and critical issues. *Illustrations showing common mistakes were preserved.	*No practice exercise *Instructor asks trainees to recall and express what they remember about certain bullet points.	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
Quality Control	Audit criteria	• General criteria • Project-based criteria	• General criteria (PRINCIPLE) • Project-based criteria (PRINCIPLE)	*Express general criteria. *Control his own work. *Audit an installed solid rivet to understand whether it is non-conforming for a given specification	*Bullet list of general criteria. *Bullet lists of specific criteria for several projects *Technical illustrations showing non-conforming situations. *Bullet list of general criteria was preserved. This information is also distributed as a reference sheet. *Bullet lists of specific criteria were preserved with the addition of how to access these lists through company systems.	*Instructor asks trainees to evaluate the rivets they installed in the workshop and decide if there are any non-conformities. *Instructor asks trainees to evaluate the rivets they installed in the workshop and decide if there are any non-conformities. *Instructor also presents a series of installed rivets which represent common non-conformities and asks trainees to audit them and share their conclusions. Then a class discussion starts regarding if the audit conclusion is valid or not.	Instructor, Presentation File Instructor, Presentation File	Performance task: The trainee is required to audit the rivet he installed earlier. The trainee is expected to check exceeding length, rivet height, back & front gaps by measuring through an appropriate tool. Then, the trainee is required to provide a valid conclusion based on his audit.
	Trimming	• When to use trimming • How to trim • Untrimmable rivets	• When to use trimming (PROCEDURE) • How to trim (PROCEDURE) • Untrimmable rivets (FACT)	*No target behavior specified *No learning outcomes were specified	*Bullet list explanation for when to trim *Bullet list explanation for how to trim *Textual information on untrimmable rivets *A decision table explaining when and how to conduct trimming. *A table showing illustrations of untrimmable rivets along with their names and codes.	*No practice exercise *No practice exercise (Trimming is a special operation that is limited to certain type of personnel with particular training and experience. Therefore, this course does not aim to teach trimming. Instead, it is aimed to provide rivet installers with a general knowledge of the phenomenon)	Instructor, Presentation File Instructor, Presentation File	No items particularly address this content piece
	Removal of non-conforming installations	•Lead and drill gun selection •How to remove installed rivet	•Lead and drill gun selection (PROCEDURE) •How to remove installed rivet (PROCEDURE)	*Remove rivet without harming the structural part *Remove a non-conforming solid rivet without causing cracks or scratches to the structural part	*Bullet list explanation for how to remove installed rivet *Illustrations showing four stages of rivet removal *A table showing appropriate lead and drill gun options for different rivet diameters *A decision table explaining how to conduct rivet removal featuring illustrations of four stages of removal. *A table showing appropriate lead and drill gun options for different rivet diameters was preserved.	*Instructor conducts a follow-along demonstration of rivet removal. *Existing practice activity was preserved. *Instructor asks trainees to remove the rivets they installed for previous activities and provide them with explanatory feedback.	Instructor, Presentation File Instructor, Presentation File	Written Item with visual: "Inspect the visual carefully. Is the holding position for the drill gun is appropriate? (Circle your answer)" Performance task: The trainee is required to remove the rivet he installed earlier. The trainee is expected to finish the operation without leaving any crack or scratch on the structural part. The trainee is also required to use an appropriate lead and drill gun.

J. Informed Consent Form

Değerli Katılımcı, ***(Turkish version that is used in the study)***

Benim ismim Emre YILMAZ ve Orta Doğu Teknik Üniversitesi Bilgisayar ve Öğretim Teknolojileri Eğitimi bölümünde doktora öğrencisiyim. Tez çalışmalarım kapsamında "TEKNİK EĞİTİM TASARIMININ, ÖĞRENENİN YETENEKLERİ, BİLGİ KAZANIMI VE UZAK TRANSFER ÜZERİNDEKİ ETKİLERİ: TÜRK HAVACILIK VE UZAY SANAYİİ ÖRNEĞİ" başlıklı bir araştırma yürütmekteyim. Bu çalışmanın amacı, belirli bir eğitim tasarımı yaklaşımının öğrenme, bilgi edinimi ve öğrenilenlerin transfer edilme düzeyi üzerindeki etkisini incelemektir.

Çalışmaya katılım gönüllülük esasına dayanmaktadır ve hiçbir kişisel bilginizi paylaşmanız gerekmemektedir. Katılımcı olarak sizden beklenen, bir anketi yanıtlamanız ve dersten önce ve sonra olmak üzere iki sınava girmenizdir. Ankete vereceğiniz yanıtlar gizli tutulacak ve yalnızca araştırmacı tarafından değerlendirilecektir. Sınavlar için ise hem dersle ilgili yazılı sorulara yanıt vermeniz hem de kıdemli eğitmenlerin gözetiminde perçin çakma işlemi gerçekleştirmeniz gerekecektir. Yazılı sınav cevaplarınız TUSAŞ Akademi'de aldığınız tüm diğer eğitimlerde olduğu gibi kurumsal ERP yazılım sisteminde depolanacaktır. Sınavların uygulamalı bölümü kıdemli eğitmenler tarafından yakından takip edilecek, tüm gerekli iş sağlığı ve güvenliği önlemleri alınacak, gerekli kişisel koruyucu donanımlar (gözlük, kulaklık, eldiven) size sağlanacak ve iş yerinde günlük olarak gerçekleştirdiğiniz standard operasyondan farklı bir durum olmayacaktır. Sınav sonuçlarınız kurum içinde veya dışında herhangi bir üçüncü kişiyle paylaşılmayacaktır. Yalnızca kısıtlı sayıdaki Akademi yöneticisi, tüm diğer sınavlarda olduğu gibi sınav sonuçlarını içeren module erişim hakkına sahip olacaktır. Bunun dışında sınav sonuçları, kimlik bilgilerinizle eşleştirilmemiş biçimde yalnızca ortalamalar üzerinden doktora tezi izleme komitesi ve doktora tezi savunma jürisi üyeleriyle paylaşılabilecektir.

Çalışma kapsamında ilk amirlerinize de bir anket uygulaması ilerleyen dönemde gerçekleştirilebilir. Bu anket, sizin dersten sonraki perçin çakma performansınızla ilgili sorular içerecektir. Amirlerle görüşmeler yapılması durumunda bu görüşme kayıtları yalnızca araştırmayla ilgili amaçlarda kullanılacaktır. Son olarak, çalışma için gereken bir analizde kullanmak üzere halihazırda takip edilmekte olan "kalite hata sayısı" bilgileriniz sistemden rapor olarak temin edilecektir.

Anket, katılımcılarda rahatsızlık yaratacak herhangi bir soru içermemektedir. Ancak çalışma öncesinde veya çalışma başladıktan sonra herhangi bir nedenle rahat hissetmezseniz, dilediğiniz anda çalışmadan ayrılabilirsiniz. Böyle bir durumda araştırmacıya durumu sözlü olarak beyan etmeniz yeterli olacaktır. Çalışma süresince öngörülen herhangi bir risk maruz kalmanız söz konusu değildir. Sınav sonuçlarınız veya kalite hata sayılarınız, yıllık performans değerlendirmeniz veya kişisel kariyer siciliniz üzerinde hiçbir etki yapmayacaktır. Öte yandan, eğer ders sonrası sınavından geçer not alırsanız, iş yeri rolü gereği almanız zorunlu olan Dolu Gövdeli Perçin Uygulamaları dersinden geçmiş sayılacaksınız.

Çalışmaya katılımınız için şimdiden teşekkür ediyorum. Daha fazla bilgi almak istereniz Orta Doğu Teknik Üniversitesi, Bilgisayar ve Öğretim Teknolojileri Eğitimi bölümü öğretim üyesi Prof. Dr. Soner Yıldırım ile iletişime geçebilirsiniz (E-mail: soner@metu.edu.tr).

Bu çalışmaya tamamen kendi irademle ve istediğim zaman çalışmadan ayrılabileceğimi bilerek katılıyorum. Çalışmanın gerekliliklerini, amacını, beni ilgilendiren potansiyel riskleri ve kişisel bilgilerimin hangi şartlar altında korunacağını anladım. Bu şartlar altında, sağlayacağım bilgilerin bilimsel

amaçlarla kullanılmasına izin veriyorum. *(Lütfen bu formu doldurup imzaladıktan sonra verileri toplayan kişiye/araştırmacıya teslim etmeyi unutmayınız.)*

Ad Soyad	Tarih	İmza	Alınacak Ders Adı
	----/----/-----		Dolu Gövdeli Perçin Uygulamaları

Dear Trainee, ***(English translation for the thesis)***

My name is Emre YILMAZ and I am a student at Middle East Technical University enrolled in the integrated Ph.D. degree program of Computer Education and Instructional Technology. I am conducting a research study entitled *The Effects of Technical Training Design on Trainees Skills, Knowledge Acquisition and Far Transfer: Case of Turkish Aerospace.* The purpose of this study is to investigate the effect of a specific technical training design guide on learning and knowledge transfer to work performance.

Participation in this study is on a voluntary basis and no personal information is required. As a participant, you will be required to fill in a reaction questionnaire, take two exams before and after the course. Your answers to the questionnaire will be kept strictly confidential and evaluated only by the researcher. For the exams, you will be expected to provide answers to written questions on the course topics, and also you will be performing rivet installation tasks under the supervision of a senior instructor. Your written answers will be preserved by the ERP training module of the company which is the case for any other training exams you take. Hands-on practice part of the exam will be overseen by a senior instructor, all necessary occupational safety measures will be taken and the application will be no different than the standard operation you carry out on a daily basis. Exam records will not be distributed to any third party. Only a limited number of managers including the researcher himself will be able to access the records.

As a part of the research, an interview or survey might be administered to your primary supervisors concerning your rivet installation performance after the course. Records of these meetings will only be used for research purposes. Lastly, the count of errors made by each trainee with the root cause of rivet installation operations will be used in the data analysis.

The questionnaire does not contain questions that may cause discomfort in the participants. However, during participation, for any reason, if you feel uncomfortable, you are free to quit at any time. In such a case, it will be sufficient to let the researcher know about your decision. In the course of the research, there is no foreseeable risk to you. Your responses, exam scores, or post-course error numbers will have no effect on your annual performance review or personal career records. On the other hand, if you obtain a passing grade in the post-test exam, you will be qualified and certified for one of your mandatory trainings.

I would like to thank you in advance for your participation in this study. For further information about the study, you can contact Prof. Dr. Soner Yıldırım from the Department of Computer Education and Instructional Technology (e-mail: soner@metu.edu.tr).

I am participating in this study totally on my own will and am aware that I can quit participating at any time. I understand the nature of the study, the potential risks to me, and the means by which my identity will be kept confidential. I give my consent for the use of the information I provide for scientific purposes. *(Please return this form to the data collector after you have filled it in and signed it).*

Name Surname	Date	Signature	Course Taken
	----/----/-----		General Solid Rivet Application

K. Ethics Committee Approval

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
MIDDLE EAST TECHNICAL UNIVERSITY

DUMLUPINAR BULVARI 06800
ÇANKAYA ANKARA/TURKEY
T: +90 312 210 22 91
F: +90 312 210 79 59
ueam@metu.edu.tr
www.ueam.metu.edu.tr

Sayı: 28620816 / 20

29 OCAK 2021

Konu : Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi : İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr. Soner YILDIRIM

Danışmanlığını yaptığınız Emre YILMAZ'ın "Teknik Eğitim Eğitim Tasarımının, Öğrenenin yetenekleri, Bilgi Kazanımı ve Uzak Transfer Üzerindeki Etkileri: Türk Havacılık ve Uzay Sanayii Örneği" başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **020-ODTU-2021** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof. Dr. Mine MISIRLISOY
İAEK Başkanı

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Yılmaz, Emre
Nationality: Turkish (TC)
Date and Place of Birth: 6 July 1987, Sivas
Marital Status: Married
Phone: +90 554 817 06 55
email: emreyilmaz46@gmail.com – contact@emreyz.com

EDUCATION

Degree	Institution	Year of Graduation
BS	METU Comp. Edu. and Inst. Tech.	2009
High School	Selcuk Anadolu High School, Sivas	2005

WORK EXPERIENCE

Year	Place	Enrollment
2018-Present	Turkish Aerospace Inc.	Academy Manager
2018-2018	Tiga Info. Tech. Inc.	Software Developer
2013-2018	METU Comp. Edu. and Inst. Tech	Research Assistant
2009-2013	Ministry of National Education	Info. Tech. Teacher

FOREIGN LANGUAGES

Advanced English

PUBLICATIONS

1. Sumuer, E., Yılmaz, E., & Yıldırım, S. (2015). *To Be or Not To Be on The Facebook? Factors Contributing to Teachers' Facebook Use for Educational*

Purposes. Paper presented at the European Conference on Educational Research, Budapest, Hungary.

2. Sumuer, E., Yılmaz, E., & Yıldırım, S. (2015). *Öğretmenlerin gözünden Facebook: Öğretmenlerin eğitim ve mesleki gelişim amaçlı kullanım profilleri*. Paper presented at 9th International Computer & Instructional Technologies Symposium, Afyonkarahisar, Turkey.

HOBBIES

Basketball, Etymology, Graphic Design, Video Games, Cinema