CHAPTER 3
Research Method

3.1 Research Paradigm & Design

When designing a research study to evaluate the integration of a Learning Management System (LMS) with a Virtual Reality (VR) platform, we consider the research paradigm and design. Below is the outline of the possible research paradigm and design options for such an evaluation:

3.1.1. Research Paradigm:

1. **Positivist Paradigm:** This paradigm focuses on an objective and quantitative approach to research. It aims to measure and analyze the integration's impact using numerical data and statistical analysis.

   The Positivist Paradigm is a philosophical and methodological approach that emphasizes objectivity, empirical observation, and the search for universal laws and causal relationships. When examining how students perceive and use Virtual Reality (VR) technology integrated with a Learning Management System (LMS) from a positivist perspective, the focus is on gathering quantitative data and identifying objective patterns and relationships.

   a) **Surveys and Questionnaires:** A positivist approach would involve administering structured surveys and questionnaires to students to gather data on their perceptions and usage of VR technology integrated with an LMS. These instruments would likely consist of closed-ended questions with predetermined response options, allowing for quantitative analysis and the identification of trends and patterns in students' perceptions, attitudes, and usage behaviors.

   b) **Usage Data and Metrics:** Positivism emphasizes the collection and analysis of objective data. In the context of VR integrated with an LMS, this could involve tracking students' usage patterns, such as the frequency and duration of their VR interactions, the specific VR activities or modules accessed, or the completion rates of VR-based assignments. These usage metrics can provide quantitative insights into how students engage with the technology within the LMS.

   c) **Experimental Design:** A positivist approach may involve conducting controlled experiments to examine the effects of VR technology integrated with an LMS on student learning outcomes and perceptions. Students could be randomly assigned to different groups, such as a control group using traditional learning methods and an experimental group using VR technology within the LMS. By comparing the results of pre- and post-tests, objective data can be collected to assess the impact of the technology on student performance and perceptions.

d) **Statistical Analysis:** Positivism relies on statistical analysis to identify patterns and relationships in the data. This may involve using statistical tests to examine the correlations between variables, conducting inferential analysis to determine the significance of differences between groups, or employing regression analysis to identify predictors of student perceptions and usage behaviors. These quantitative analyses allow for objective interpretations of the data and the identification of generalizable findings.

By adopting a positivist perspective in studying students' perceptions and usage of VR technology integrated with an LMS, researchers can gather quantitative data to identify objective patterns, relationships, and generalizable findings. This approach provides a systematic and empirical foundation for understanding how students engage with and perceive the technology within the LMS context.

2. **Interpretivist Paradigm:** This paradigm emphasizes understanding and interpretation of experiences, meanings, and social interactions related to the integration. It involves qualitative methods, such as interviews, observations, and case studies, to explore the subjective perspectives of users and stakeholders.

3.1.2 Research Design:

3.1.2.1 **Case Study Design:** This design focuses on in-depth examination of a specific integration implementation. We will select one or more educational institutions or organizations that have adopted the integrated LMS-VR platform and conduct extensive observations, interviews, and data analysis to understand the benefits, challenges, and outcomes.

3.1.2.2 **Mix Method Design:** This design combines quantitative and qualitative data collection and analysis methods based on secondary data collected.

3.1.3 Data Collection Methods:

Documentation Analysis: Analyze relevant documentation, such as user logs, system performance reports, or feedback forms, to supplement the findings and gain additional insights.

3.1.4 Limitation:

It's crucial to outline the limitations of the research approach while presenting the limitations for a thesis on the assessment of Virtual Reality (VR) training programs using the reverse Kirkpatrick model. The following are some significant restrictions that could be stated:

1. **Evaluation Scope Limitation:** The thesis focuses only on Level 1 (Reaction) and Level 2 (Learning) of the Kirkpatrick model. Levels 3 (Behaviour) and 4 (Results), which measure the long-term impact of training on behaviour and organizational results respectively, are not assessed within the timeframe of this study. This limitation restricts the ability to fully determine the effectiveness of VR training in changing behaviours and achieving desired outcomes in the workplace.
2. **Time Constraints:** The assessment of Levels 3 and 4 is deferred to a period of six months post-training to capture the long-term effects accurately. This delay presents a significant limitation as immediate findings might not reflect long-term training efficacy and the true impact on participants' performance and organizational goals.
3. **Variability in Course Content:** The variability in VR training content across different organizations poses a limitation in standardizing the evaluation process. Since the pre and post-tests are tailored to the specific courses chosen by each organization, comparing results across different settings or drawing generalized conclusions about the efficacy of VR training becomes challenging.
4. **Data Collection Challenges:** Relying on surveys and questionnaires for data collection introduces limitations related to response rates, the honesty and accuracy of responses, and the potential bias in self-reported data. These factors can affect the reliability and validity of the evaluation results.
5. **Technological Constraints:** The effectiveness of VR training can also be influenced by the technical quality and user-friendliness of the VR systems employed. Issues such as hardware limitations, software glitches, or poor user interface design can impact the learning experience and, consequently, the evaluation outcomes.
6. **Sample Diversity:** The diversity of participants in terms of their familiarity with VR technology, learning preferences, and technological proficiency may also limit the

applicability of findings. Participants who are not accustomed to using VR may react differently, which could skew the results related to the perceived usability and learning effectiveness of VR training.

By addressing these limitations, the thesis improves its scholarly depth and trustworthiness by presenting a clearer picture of the context and restrictions that the study findings are generated under.

3.2 Research Object & Subject

3.2.1 Research Object:

The research object refers to the specific entity or system being studied. In this case, the research object is the integration of a Learning Management System (LMS) with a Virtual Reality (VR) platform. The focus of the study would be to evaluate the effectiveness, benefits, challenges, and impact of this integration in an educational or training context.

3.2.2 Research Subject:

The research subject refers to the individuals, groups, or organizations that already use VR in their training or educational programs based on the secondary data collected.

For the evaluation of the LMS-VR platform integration, potential research subjects in the secondary data should include:

1. **Trainee:** The study could involve students who use the integrated LMS-VR platform as part of their learning or training activities. Their experiences, perceptions, and learning outcomes could be assessed through surveys, interviews, or observations.
2. **Instructors or Trainers:** The research could involve instructors or trainers who utilize the integrated LMS-VR platform to deliver educational content or training sessions. Their perspectives on the effectiveness, ease of use, and impact on teaching and learning could be explored through interviews or surveys.
3. **Administrators or IT Professionals:** The study could also involve administrators or IT professionals responsible for implementing and managing the integrated LMS-VR platform. Their insights on technical aspects, infrastructure requirements, support needs, and integration challenges could be valuable for evaluating the overall integration process.
4. **Educational Institutions or Organizations:** The research may involve educational institutions or organizations that have adopted the LMS-VR platform integration. Case studies or interviews with representatives from these institutions can provide valuable

insights into the decision-making process, implementation strategies, and overall experiences of integrating the LMS with VR technology.

It's important to select research subjects that represent a diverse range of perspectives, roles, and experiences to gather comprehensive data and ensure the validity of the evaluation. The specific research subjects will depend on the context and scope of the study, as well as the availability of the data.

3.3 Population & Sample

When studying how students perceive and use Virtual Reality (VR) technology integrated with a Learning Management System (LMS), it is important to consider the concepts of population and sample. These concepts relate to the group of individuals being studied and the subset of that group that is included in the research, respectively.

When determining the sample, we may use various sampling techniques, such as random sampling, stratified sampling, or convenience sampling. The choice of sampling method depends on factors like the research objectives, available resources, and feasibility.

The size of the sample depends on factors such as the research design, statistical power, and expected effect size.

It is important to acknowledge that the findings from the selected sample may not perfectly represent the entire population. However, by employing appropriate sampling techniques and ensuring sample representativeness, researchers can increase the likelihood of obtaining meaningful insights into how students perceive and use VR technology integrated with an LMS. Additionally, we should consider factors like demographic characteristics, prior experience with VR, and educational context when selecting the sample. This consideration helps ensure that the sample represents the diversity and relevant attributes of the target population, enhancing the validity and applicability of the research findings.

a) **Population:**

The population refers to the entire group of individuals or entities that the research study aims to generalize its findings to. In the case of evaluating the integration of an LMS with a Virtual Reality (VR) platform, the population could include:

a. Trainee: The population could consist of internal auditor from various governmental organization.

b. Instructors or Trainers: instructors or trainers from internal auditor, who are responsible for delivering educational content or training sessions using the integrated LMS-VR platform.

c. Educational Institutions or Organizations: Government Internal Auditor of Indonesia

Sample:

The sample consist of 200 population from various ministry and governmental organization that participate onsite training.

3.4 Measurement

When evaluating the integration of a Learning Management System (LMS) with a Virtual Reality (VR) platform, several measurements can be used to assess different aspects of the integration. Here are some key measurements:

1. **Learning Outcomes:** Measure the impact of the LMS-VR integration on learning outcomes. This can include assessments of knowledge acquisition, skill development, performance improvement, or learner satisfaction. Quantitative measures, such as pre and post-tests or performance evaluations, can be used to compare the learning outcomes between the traditional LMS and the integrated LMS-VR platform.

   One of the theories that can be use to measure learning outcome is the 4-level reverse assessment Kirkpatrick.

Figure 2. Diagram of Four Level Reverse Assessment Kirkpatrick.

Developed by Donald Kirkpatrick, this model provides a framework for evaluating training programs and assessing their effectiveness. The four levels of evaluation are as follows:

- **Level 1: Reaction -** This level measures learner satisfaction and perceptions of the LMS-VR integration. It involves gathering feedback from learners through surveys, interviews, or focus groups to assess their subjective experience and satisfaction with the learning environment.
- **Level 2: Learning -** This level assesses the knowledge and skills acquired by learners as a result of the LMS-VR integration. It involves evaluating learning outcomes through pre- and post-tests, quizzes, or assessments to determine the extent of knowledge acquisition and skill development.
- **Level 3: Behavior -** This level focuses on evaluating whether learners apply their acquired knowledge and skills in real-world settings. It examines whether the integration of LMS-VR has influenced learners' behavior (Brooke, 1996) (Tcha-Tokey, Christmann, Loup-Escande, & Richir, 2016) and performance in their respective domains. This level of evaluation often involves observations, simulations, or job performance assessments.
- **Level 4: Results -** This level measures the overall impact of the LMS-VR integration on organizational or educational outcomes. It aims to determine whether the integration has resulted in tangible benefits, such as improved performance, increased productivity, or enhanced learner outcomes.

By employing Kirkpatrick's Four-Level Training Evaluation Model, researchers and educators can assess the learning impact of LMS-VR integration from multiple perspectives. This model allows for a comprehensive evaluation that considers learner satisfaction, knowledge acquisition, skill application, and overall outcomes. By gathering data at each level, researchers can gain insights into the effectiveness of the integration and identify areas for improvement in terms of learning outcomes and learner satisfaction.

2. **User Engagement:** Assess the level of user engagement with the integrated LMS-VR platform. This can be measured through user activity logs, such as the frequency of logins, time spent on the platform, or the number of interactions with VR content. Surveys or interviews can also gauge the subjective experience of user engagement and perceived motivation.

One theory that can be used to measure user engagement of LMS-VR integration on learning outcomes is the Flow Theory, proposed by Mihaly Csikszentmihalyi. He said, "flow is a state in which people are so involved in an activity that nothing else seems to matter; the experience is so enjoyable that people will continue to do it even at great cost, for the sheer sake of doing it." (Csikszentmihalyi, 2013)

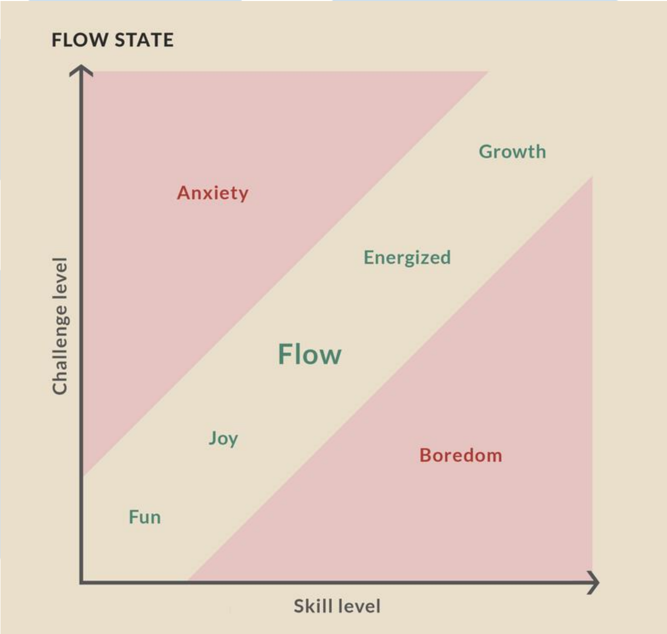

Figure 3. State of Flow. (Mike Oppland, 2016)

Flow refers to a state of optimal engagement and immersion in an activity where individuals experience deep enjoyment and focused concentration. This theory can be applied to assess the level of engagement and satisfaction of users within the LMS-VR integration context.

Flow Theory suggests that several factors contribute to the experience of flow, including:

a. **Clear Goals:** Users should have clear and specific goals within the LMS-VR integration, such as completing a VR module or achieving specific learning outcomes. Well-defined goals provide users with a sense of direction and purpose, enhancing their engagement.

b. **Challenge-Skill Balance:** Users should perceive the LMS-VR integration as challenging yet manageable. If the activities or content are too easy, users may become bored, whereas if they are too difficult, users may become frustrated.

Finding an optimal balance that matches users' skill levels with the level of challenge presented by the VR activities can promote engagement.

c. **Immediate Feedback:** Users should receive immediate and informative feedback within the LMS-VR integration. Feedback can come in various forms, such as progress indicators, performance evaluations, or interactive responses within the VR environment. Timely feedback allows users to monitor their progress and adjust their actions accordingly, contributing to a sense of engagement.

d. **Immersion and Concentration:** The LMS-VR integration should provide an immersive and captivating experience that holds users' attention. Elements such as realistic graphics, interactive simulations, and compelling narratives can enhance immersion and promote sustained focus.

To measure user engagement within the LMS-VR integration, researchers and educators can employ a combination of qualitative and quantitative methods, including:

- Surveys or questionnaires to gather self-reported measures of engagement, satisfaction, and flow experiences.
- Observations and interviews to capture qualitative data on users' experiences, motivations, and levels of immersion.
- Usage analytics and tracking data within the LMS-VR system to assess users' interaction patterns, time spent, completion rates, and task performance.
- Learning outcomes assessments, such as knowledge tests, skill assessments, or performance evaluations, to measure the impact of engagement on learning outcomes.

By applying the principles of Flow Theory and employing a range of assessment methods, researchers can gain insights into the level of user engagement and satisfaction within the LMS-VR integration context. This understanding can help educators and designers optimize the integration to enhance engagement, promote effective learning, and improve user experiences.

3. **User Satisfaction:** Evaluate user satisfaction with the LMS-VR integration. Surveys, questionnaires, or Likert-scale ratings can be used to gather feedback on usability, functionality, content quality, and overall user experience. Qualitative methods like interviews or focus groups can provide in-depth insights into user perceptions, preferences, and suggestions for improvement.

One theory that can be used to measure user satisfaction in LMS-VR integration on learning outcomes is the Expectancy-Confirmation Theory (ECT). The ECT, initially proposed by Richard L. Oliver, focuses on individuals' expectations and confirmation of those expectations as determinants of satisfaction.

The theory suggests that satisfaction is influenced by two key factors:

a. **Expectations:** Users develop certain expectations about the LMS-VR integration based on their prior experiences, information, and perceptions. These expectations could include aspects such as the usability, effectiveness, relevance of content, interactivity, and technical performance of the system. Users compare their expectations with their actual experiences to assess satisfaction.

b. Confirmation occurs when users perceive that their expectations **Confirmation:** of the LMS-VR integration have been met or exceeded. Positive confirmation leads to higher levels of satisfaction, while negative confirmation can result in dissatisfaction. Users evaluate the system based on the extent to which it aligns with their initial expectations and provides a positive learning experience.

To measure user satisfaction within the LMS-VR integration context, researchers and educators can employ various assessment methods, such as:

- **Surveys and questionnaires:** These instruments can include items that directly measure user satisfaction with the LMS-VR integration. Likert-scale or semantic differential questions can be used to gather quantitative data on users' satisfaction levels, allowing for comparisons and statistical analysis.
- **Interviews or focus groups:** Qualitative methods can be used to gain in-depth insights into users' satisfaction, perceptions, and experiences. Open-ended questions can provide rich data on specific aspects of satisfaction, areas of improvement, or unmet expectations.
- **Usage and interaction data:** Tracking user behaviour within the LMS-VR system can provide indirect indicators of satisfaction. For example, monitoring the frequency and duration of user engagement, completion rates of VR activities, or participation in collaborative learning within the system can offer insights into users' satisfaction and engagement levels.

- **Post-use evaluations:** Conducting post-use evaluations after specific learning activities or modules can assess user satisfaction with those specific components. These evaluations can be in the form of feedback forms, reflection exercises, or structured assessments of users' perceived benefits and satisfaction levels.

By applying the Expectancy-Confirmation Theory and utilizing a combination of quantitative and qualitative assessment methods, researchers can gain a comprehensive understanding of user satisfaction within the LMS-VR integration context. This knowledge can inform improvements in the design, implementation, and user support of the integration, ultimately enhancing user satisfaction and optimizing learning outcomes.

4. **Technological Performance**: Assess the technological performance of the integrated LMS-VR platform. This can include measurements of system reliability, response time, scalability, compatibility with different VR devices, and network bandwidth requirements. Technical measurements can be obtained through system logs, performance monitoring tools, or surveys targeting system administrators or IT professionals.

A theory that can be used to measure technological performance in LMS-VR integration on learning outcomes is the Technology Acceptance Model (TAM). TAM, initially proposed by Fred Davis, focuses on individuals' perceptions and attitudes toward technology adoption and usage.

The key constructs of TAM that are relevant to measuring technological performance in the LMS-VR integration context are:

a. **Perceived Usefulness:** This refers to the degree to which users perceive that the LMS-VR integration enhances their learning outcomes, knowledge acquisition, skill development, or performance improvement. It assesses users' beliefs about the value and benefits they expect to derive from using the technology.

b. **Perceived Ease of Use:** This construct measures users' perceptions of the ease and convenience of using the LMS-VR integration. It evaluates factors such as system usability, interface design, navigation, and user-friendliness. Users' perceptions of ease of use influence their willingness to engage with the technology and can impact their learning outcomes.

To measure technological performance within the LMS-VR integration context, researchers and educators can utilize the following assessment methods:

- Surveys and questionnaires: These instruments can include items that directly measure users' perceptions of the technological performance of the LMS-VR integration. Likert-scale or semantic differential questions can be used to gather quantitative data on users' perceptions of usefulness and ease of use, enabling comparisons and statistical analysis.

- System usability testing: Conducting usability testing sessions can provide insights into users' interactions with the LMS-VR integration. Through direct observation and user feedback, researchers can identify usability issues, areas of improvement, and potential barriers to effective usage.

- Performance metrics: Tracking and analysing system performance metrics can provide objective measures of technological performance. This can include metrics related to system responsiveness, loading times, stability, and compatibility across different devices and platforms. Performance metrics can indicate the efficiency and effectiveness of the LMS-VR integration in supporting users' learning outcomes.

- User feedback and support requests: Monitoring user feedback, support tickets, or helpdesk inquiries can provide indications of users' technological experiences and performance issues. Analysing user-reported problems and concerns can help identify areas where the LMS-VR integration may be hindering learning outcomes and inform necessary improvements.

The Technology Acceptance Model and utilizing a combination of quantitative and qualitative assessment methods, we can gain insights into users' perceptions of the technological performance of the LMS-VR integration. This understanding can guide the refinement and optimization of the technology to enhance its effectiveness, usability, and impact on learning outcomes.

5. **Training/Course Efficiency:** Evaluate the efficiency and effectiveness of training programs delivered through the LMS-VR integration. This can include measurements of training completion rates, time-to-competency, cost savings compared to traditional training methods, or reduction in errors or accidents. Comparative analysis between the integrated LMS-VR platform and other training approaches can provide insights into its effectiveness.

   When applying Efficiency Theory to measure training/course efficiency in the LMS-VR integration context, the following aspects can be considered:

   a. **Time Efficiency:** This aspect assesses the effectiveness of the LMS-VR integration in saving time compared to traditional learning methods. It involves measuring the time required for learners to acquire knowledge, develop skills, or improve performance using the LMS-VR integration. Comparisons can be made between the time taken in the LMS-VR environment and the time taken using alternative learning methods.

   b. **Effort Efficiency:** Effort efficiency focuses on the cognitive and physical effort required from learners to achieve desired learning outcomes. It evaluates the level of mental and physical workload associated with using the LMS-VR integration. This can include measures such as task completion rates, error rates, or subjective ratings of perceived effort.

   c. **Resource Utilization:** This aspect examines the allocation and utilization of resources within the LMS-VR integration. It involves assessing the extent to which the integration optimizes the use of available resources such as hardware, software, instructor support, or learning materials. Efficiency can be measured by considering resource utilization rates, cost-effectiveness, or the minimization of redundant or unnecessary resources.

To measure training/course efficiency within the LMS-VR integration context, researchers and educators can utilize the following assessment methods:

1) **Comparative Studies**: Conducting comparative studies between the LMS-VR integration and alternative learning methods can provide insights into the efficiency gains. This can involve comparing learning outcomes, knowledge acquisition rates, skill development rates, or performance improvement rates between the different approaches.

2) **Time and Effort Metrics:** Tracking and analysing time spent by learners in the LMS-VR environment, completion rates of tasks or modules, or subjective ratings of perceived effort can provide quantitative measures of training/course efficiency. These metrics can help assess the effectiveness of the LMS-VR integration in optimizing time and effort.

3) **Cost-Benefit Analysis:** Performing a cost-benefit analysis can provide insights into the resource utilization and cost-effectiveness of the LMS-VR integration. This analysis can involve considering the costs associated with developing and maintaining the integration, as well as the benefits in terms of improved learning outcomes, performance, or satisfaction.

4) **Learner Feedback:** Collecting feedback from learners through surveys, interviews, or focus groups can provide qualitative insights into their perceptions of training/course efficiency. Open-ended questions can allow learners to express their views on the time and effort required, resource utilization, and overall efficiency of the LMS-VR integration.

When implementing Efficiency Theory and employing a combination of quantitative and qualitative assessment methods, researchers can gain insights into the training/course efficiency of the LMS-VR integration. This understanding can guide the optimization of the integration to ensure maximum utilization of resources and effective achievement of learning outcomes while minimizing time and effort requirements.

6. **Content Evaluation:** Assess the quality and relevance of VR content within the integrated platform. This can include evaluations of instructional design principles, immersive and interactive elements, realism, user feedback mechanisms, and alignment with learning objectives. Expert reviews, user feedback, or rating scales can be used to evaluate the content.

Theory that can be used to evaluate content in LMS-VR integration on learning outcomes is the Cognitive Load Theory (CLT). Cognitive Load Theory, developed by John Sweller, focuses on the cognitive processes involved in learning and how the load on working memory affects learning outcomes.
When applying Cognitive Load Theory to evaluate content in LMS-VR integration, the following aspects can be considered:

a. **Intrinsic Cognitive Load:** This refers to the inherent complexity of the learning content. It relates to the difficulty level of the materials, the complexity of the concepts being taught, and the extent to which the content aligns with learners' prior knowledge. Evaluating intrinsic cognitive load involves assessing the clarity, coherence, and organization of the content.
b. **Extraneous Cognitive Load:** Extraneous cognitive load refers to the unnecessary cognitive processing imposed by instructional design elements or presentation formats. It includes elements such as distracting visuals, excessive text, or irrelevant information that can overload learners' working memory. Evaluating extraneous cognitive load involves identifying and eliminating or minimizing elements that hinder learning.
c. **Germane Cognitive Load:** Germane cognitive load refers to the cognitive processing that supports schema acquisition, automation of skills, and deep understanding of the content. It involves engaging learners in meaningful learning activities, providing opportunities for reflection, and promoting active processing of information. Evaluating germane cognitive load involves assessing the extent to which the content encourages deeper understanding, problem-solving, and critical thinking.

To evaluate content within the LMS-VR integration context, researchers and educators can utilize the following assessment methods:

- **Cognitive Load Measures:** Various methods can be used to measure cognitive load, including self-report measures, subjective ratings, or physiological measures such as eye-tracking or brain imaging. These measures can provide insights into learners' cognitive load while engaging with the content.
- **Learning Outcomes Assessments:** Assessing learning outcomes such as knowledge acquisition, skill development, or performance improvement can help evaluate the effectiveness of the content. This can be done through pre- and post-tests, quizzes, assessments, or performance evaluations that measure the extent to which the content has facilitated learning.
- **Learner Feedback:** Gathering feedback from learners through surveys, interviews, or focus groups can provide qualitative insights into their perceptions of the content. Learners' opinions on the clarity, relevance, engagement, and organization of the content can help identify areas for improvement.

- **Observations:** Conducting observations of learners' engagement, behavior, and interactions with the content can provide valuable information about their level of involvement and understanding. This can involve direct observation, video recordings, or screen captures of learners' interactions with the LMS-VR integration.

By using this we can evaluate the effectiveness of content within the LMS-VR integration context. This understanding can guide the design and refinement of content to optimize learning outcomes, facilitate knowledge acquisition, skill development, performance improvement, and enhance learner satisfaction.

7. **Accessibility and Inclusivity**: Evaluate the accessibility and inclusivity of the LMS-VR integration. This can involve measuring compatibility with assistive technologies, usability for individuals with disabilities, and considerations for diverse learner needs. Compliance with accessibility guidelines, user feedback, or expert evaluations can be used for assessment.

   To measure accessibility and inclusivity in LMS-VR integration on learning outcomes is the Universal Design for Learning (UDL) framework. UDL is an educational framework that promotes inclusive instructional practices and provides multiple means of representation, expression, and engagement to meet the diverse learning needs of all learners.

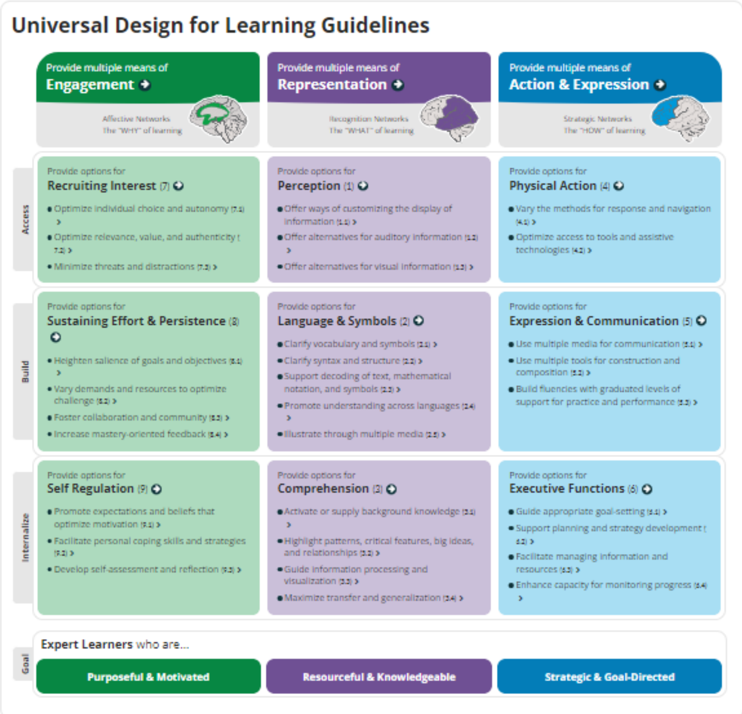

Figure 4. Universal Design for Learning Guidelines. (CAST, 2018)

When applying the Universal Design for Learning framework to measure accessibility and inclusivity in LMS-VR integration, the following aspects can be considered:

a. **Multiple Means of Representation:** This aspect focuses on providing various ways of presenting information to cater to different learning styles, preferences, and needs. It involves offering content in multiple formats, such as text, audio, visuals, or interactive elements, to support knowledge acquisition and understanding.

b. **Multiple Means of Expression:** This aspect emphasizes providing learners with multiple ways to demonstrate their understanding, skills, and knowledge. It involves offering diverse options for learners to express themselves, such as through written assignments, oral presentations, multimedia projects, or interactive assessments.

c. **Multiple Means of Engagement:** This aspect focuses on providing learners with various opportunities for engagement and motivation. It involves offering choices in learning activities, providing interactive and immersive experiences, and fostering learner autonomy and self-regulation.

To measure accessibility and inclusivity within the LMS-VR integration context, researchers and educators can utilize the following assessment methods:

- **Accessibility Audits:** Conducting accessibility audits can help identify potential barriers that may hinder learners with disabilities or diverse needs from accessing and engaging with the LMS-VR integration. These audits can involve evaluating the compatibility of the system with assistive technologies, assessing the availability of alternative formats for content, and checking for compliance with accessibility standards.
- **Learner Surveys and Interviews:** Gathering feedback from learners through surveys or interviews can provide insights into their perceptions of accessibility and inclusivity within the LMS-VR integration. Specific questions can be asked regarding their access to content, their ability to navigate the system, and their overall satisfaction with the inclusive features provided.
- **User Testing:** Involving learners with diverse abilities and needs in user testing sessions can help identify usability and accessibility issues within the LMS-VR integration. Direct observation and feedback can provide valuable insights into the barriers they encounter and potential improvements needed to enhance accessibility and inclusivity.
- **Learning Outcomes Assessments:** Assessing learning outcomes, such as knowledge acquisition, skill development, or performance improvement, can help evaluate the effectiveness of the LMS-VR integration in meeting the diverse needs of learners. This can involve analysing performance data, comparing outcomes across different learner profiles, or conducting subgroup analyses to identify potential disparities in learning outcomes.

When we use the Universal Design for Learning framework and utilizing a combination of quantitative and qualitative assessment methods, researchers can measure the accessibility and inclusivity of the LMS-VR integration. This understanding can guide the design and implementation of inclusive features, ensure equitable learning experiences, and optimize learning outcomes for all learners.

It is important to select the appropriate measurement methods and tools based on the research objectives, research design, target audience, and available resources. Combining quantitative and qualitative measurements can provide a comprehensive understanding of the integration's impact and identify areas for improvement.

3.5 Data Collecting Method

When collecting data for a thesis on integrating virtual reality (VR) in a learning management system (LMS), using the following data collection methods:

1. **Surveys:** Design and administer surveys to gather information from students, teachers, or administrators regarding their perceptions, attitudes, and experiences with VR integration in the LMS. This can provide insights into the acceptance, usability, and effectiveness of VR as a learning tool.

2. **Interviews:** Conduct interviews with experts in the field of education technology, instructional designers, VR developers, or educators who have experience with VR integration in LMS. Through interviews, we can gain in-depth understanding, explore challenges, and identify best practices related to VR integration.

3. **Observation and Analysis:** Observe VR-based learning sessions within the LMS to collect qualitative and quantitative data. This can involve observing student engagement, interaction patterns, learning outcomes, and any challenges or benefits associated with VR integration.

4. **Pre- and Post-Assessments:** Administer pre- and post-assessment tests to students who undergo VR-based learning experiences within the LMS. This can help evaluate the impact of VR integration on learning outcomes, retention, or knowledge transfer compared to traditional methods.

5. **Usage Data:** Collect and analyses usage data from the LMS, focusing on VR-related activities. This includes tracking the frequency of VR module usage, the time spent on VR activities, or specific actions taken by users. This data can provide insights into engagement levels and patterns of VR adoption within the LMS.

6. **User Feedback:** Encourage students and instructors to provide feedback on their experiences with VR integration in the LMS through online platforms, forums, or

feedback forms. This qualitative data can offer valuable insights into user satisfaction, challenges faced, and suggestions for improvement.

7. **Comparative Studies:** Compare the performance and engagement levels of students using VR-based learning modules within the LMS to those using traditional learning methods. This can involve conducting controlled experiments or quasi-experimental studies to evaluate the effectiveness and advantages of VR integration.

3.6 Data Analysis

When conducting an evaluation of the integration of a Learning Management System (LMS) with a Virtual Reality (VR) platform, the data analysis process plays a crucial role in deriving meaningful insights from the collected data. Below are key considerations for data analysis in such an evaluation:

3.6.1 Quantitative Data Analysis

Quantitative data analysis plays a crucial role in assessing the impact of LMS-VR integration on learning outcomes, including knowledge acquisition, skill development, performance improvement, and learner satisfaction. By employing rigorous statistical techniques and analytical methods, researchers can delve into the rich dataset generated through the integration of learning management systems (LMS) and virtual reality (VR) technologies. This analysis enables a comprehensive understanding of the quantitative patterns, trends, and relationships that emerge from the data, providing valuable insights into the effectiveness and efficacy of LMS-VR integration in enhancing learning outcomes. Through quantitative data analysis, researchers can uncover evidence-based findings that inform educational practices, optimize instructional design, and support evidence-driven decision-making for educators and stakeholders in the field of LMS-VR integration.

- **Descriptive Statistics:** Calculate summary statistics such as means, medians, standard deviations, or frequencies to describe the quantitative data collected. This can include data related to learning outcomes, user engagement, user satisfaction ratings, or technological performance.

  To calculate the user satisfaction with gained knowledge on a skill can be subjective.

  KS (Knowledge Score) be a numerical representation of the user's knowledge on a particular skill (e.g., on a scale from 0 to 100).

US (User Satisfaction) be a numerical representation of the user's satisfaction (e.g., on a scale from 0 to 100). A simple formula that combines these two factors:

$$\mathbf{US} = \boldsymbol{w} \cdot \mathbf{KS} + (\mathbf{1} - \boldsymbol{w}) \cdot \mathbf{A}$$

Where:
w is the weight assigned to the knowledge score, indicating the importance of knowledge in determining satisfaction.
A is an additional factor that can represent other aspects contributing to user satisfaction.

- **Comparative Analysis:** Conduct statistical tests (e.g., t-tests, chi-square tests) to compare the data between different groups or conditions. For example, compare learning outcomes between the traditional LMS and the integrated LMS-VR platform or compare user engagement levels between different user groups.
- **Correlation Analysis:** Explore relationships between variables using correlation analysis to determine if there are associations between factors such as user satisfaction and learning outcomes or user engagement and learning performance.

3.6.2 Qualitative Data Analysis

Qualitative data analysis is a fundamental approach to gaining deeper insights into the complex and multifaceted aspects of learning outcomes in the context of LMS-VR integration. By employing qualitative research methods, researchers can explore the nuances, perspectives, and experiences of learners, educators, and stakeholders involved in the integration process. Through in-depth interviews, focus groups, observations, and textual analysis, qualitative data analysis allows for a comprehensive exploration of knowledge acquisition, skill development, performance improvement, and learner satisfaction. By capturing the richness and context of participants' experiences, this analysis uncovers valuable insights into the underlying factors, processes, and mechanisms that contribute to or hinder successful learning outcomes. Qualitative data analysis not only complements quantitative analysis but also provides a holistic understanding of the multifaceted dimensions of learning within the LMS-VR integration landscape.

- **Thematic Analysis:** Identify recurring themes, patterns, or categories within qualitative data, such as interview transcripts or open-ended survey responses. This can involve coding the data, grouping related themes, and interpreting the meaning behind the themes.
- **Content Analysis:** Analyze the content of qualitative data, such as textual feedback or comments, to identify key topics, sentiments, or opinions expressed by users. This can involve categorizing the content into different aspects and assessing the frequency or sentiment associated with each aspect.
- **Interpretation and Synthesis:** Look for commonalities and divergences in qualitative data to develop an overall interpretation of user experiences, challenges, or suggestions related to the LMS-VR integration. Integrate qualitative findings with quantitative data to gain a comprehensive understanding of the integration's impact.

3.6.2 Mixed-Methods Integration

The integration of mixed methods research design in evaluating learning outcomes within the LMS-VR integration context offers a comprehensive and multifaceted approach to understanding the complex dynamics at play. By combining both quantitative and qualitative data collection and analysis techniques, researchers can gain a deeper understanding of **knowledge acquisition, skill development, performance improvement, and learner satisfaction.** This mixed method integration allows for the exploration of not only the numerical trends and statistical relationships but also the underlying contextual factors, experiences, and perceptions of individuals involved in the learning process. By leveraging the strengths of both quantitative and qualitative methodologies, the mixed method approach provides a more robust and holistic perspective on the effects and effectiveness of LMS-VR integration on learning outcomes. Through the integration of diverse data sources and analysis methods, this research design contributes to a richer understanding of the multifaceted aspects and potential benefits of LMS-VR integration in facilitating enhanced learning outcomes.

- **Triangulation:** Compare and contrast the findings from quantitative and qualitative data to identify convergence or divergence in the results. Triangulation helps strengthen the validity and reliability of the overall evaluation by considering multiple perspectives and data sources.

Figure 5. Triangulation Analysis. (Faith Alele; Bunmi Malau-Aduli, 2023)

- **Data Integration:** Integrate quantitative and qualitative data at different stages of the analysis to provide a more comprehensive understanding of the integration. For example, qualitative data can be used to provide context or explanation for quantitative findings, or quantitative data can be used to support or validate qualitative themes.
- **Reporting and Visualization:** Summarize and present the findings in a clear and concise manner. Use tables, charts, or graphs to visually represent quantitative data, such as comparison charts, histograms, or scatterplots. Qualitative findings can be presented using quotes, themes, or illustrative examples.

Interpret and discuss the results, highlighting key insights, trends, or implications. Relate the findings back to the research objectives and provide recommendations for improving the LMS-VR integration based on the analysis.

3.7 Limitation

It's crucial to outline the limitations of the research approach while presenting the limitations for a thesis on the assessment of Virtual Reality (VR) training programs using the reverse Kirkpatrick model. The following are some significant restrictions that could be stated:

1. **Evaluation Scope Limitation:** The thesis focuses only on Level 1 (Reaction) and Level 2 (Learning) of the Kirkpatrick model. Levels 3 (Behavior) and 4 (Results), which measure the long-term impact of training on behavior and organizational results respectively, are not assessed within the timeframe of this study. This limitation restricts the ability to fully determine the effectiveness of VR training in changing behaviors and achieving desired outcomes in the workplace.
2. **Time Constraints:** The assessment of Levels 3 and 4 is deferred to a period of six months post-training to capture the long-term effects accurately. This delay presents a significant limitation as immediate findings might not reflect long-term training efficacy and the true impact on participants' performance and organizational goals.
3. **Variability in Course Content:** The variability in VR training content across different organizations poses a limitation in standardizing the evaluation process. Since the pre

and post-tests are tailored to the specific courses chosen by each organization, comparing results across different settings or drawing generalized conclusions about the efficacy of VR training becomes challenging.

4. **Data Collection Challenges:** Relying on surveys and questionnaires for data collection introduces limitations related to response rates, the honesty and accuracy of responses, and the potential bias in self-reported data. These factors can affect the reliability and validity of the evaluation results.
5. **Technological Constraints:** The effectiveness of VR training can also be influenced by the technical quality and user-friendliness of the VR systems employed. Issues such as hardware limitations, software glitches, or poor user interface design can impact the learning experience and, consequently, the evaluation outcomes.
6. **Sample Diversity:** The diversity of participants in terms of their familiarity with VR technology, learning preferences, and technological proficiency may also limit the applicability of findings. Participants who are not accustomed to using VR may react differently, which could skew the results related to the perceived usability and learning effectiveness of VR training.

By addressing these limitations, the thesis improves its scholarly depth and trustworthiness by presenting a clearer picture of the context and restrictions that the study findings are generated under.