Traceability in the Context of Formative Assessment in a Knowledge Management and Educational Environment

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***Abstract*— Traceability, commonly applied in industries such as manufacturing and software development, refers to the ability to track and trace elements across different stages of a process. In the context of a knowledge management environment, traceability has become increasingly significant for enhancing user experience, particularly in the development and assessment of learning materials. This article reviews existing literature on traceability systems, discusses their application in the creation and assessment of educational content, and presents a traceability-based process flow diagram. Finally, a use case is provided to demonstrate how traceability can be implemented to improve the quality of formative assessments, feedback mechanisms, and learning outcomes.**

***Keywords*— Traceability, Assessment, Item development, User experience, Knowledge management**

ICTIEE Track: Assessment of Effective Teaching
ICTIEE Sub-Track: Diversifying Assessment Approaches: Success Stories

I. INTRODUCTION

IN a knowledge management environment, developing high-quality assessment items that cater to learners' needs is critical for ensuring educational effectiveness. Assessment items include quizzes, tests, and exams, which evaluate learners' comprehension of the material. One of the significant challenges in creating these items is ensuring that they align with learning objectives and provide consistent feedback to users. Traceability systems can address these challenges by allowing educators and administrators to track the development of formative assessment items and monitor their use, revision, and effectiveness over time. The aim of this paper is to explore the role of traceability in enhancing user experience in assessment item development within a knowledge management framework. It will review the existing literature on traceability, discuss the traceability process in a structured workflow, and demonstrate how a traceability system can be applied through a practical use case.

II. LITERATURE SURVEY

Definition and Concepts of Traceability: as defined in ISO9000:2015, Clause 3.6.13 defines traceability as the ability to trace the history, application or location of an object (3.6.1) [Note 1 to entry: When considering a product (3.7.6) or a service (3.7.7), traceability can relate to: — the origin of materials and parts; — the processing history; — the distribution and location of the product or service after delivery.] Traceability, in its simplest form, refers to the ability to track and document the history, location, and use of an item or process throughout its lifecycle. It is commonly applied in manufacturing, where tracking the components of a product through its supply chain is essential to maintain quality. In recent years, the concept has been increasingly applied to other domains, such as software development and education. Traceability in software engineering is used to link requirements to their corresponding test cases, design documents, and implementation code, which ensures that all features are accounted for during product development (Ramesh & Jarke, 2001). In educational environments, traceability has gained attention as a tool to enhance content development and user experience. As reported by (Irribarra, D.T., et al., 2015), computer-based, online assessments modelled, designed, and evaluated for adaptively administered invariant measurement are uniquely suited to defining and maintaining traceability to standardized units in education.

A. Traceability in Knowledge Management

As per Clause 3.8.2 of ISO9000:2015, the delivery of information in the context of knowledge transmission is defined in the purview of service as the delivery of an intangible product. A service is generally experienced by the customer. Knowledge management environments focus on collecting, sharing, and organizing information to improve learning and decision-making processes. In this context, traceability is key to ensuring that the development of learning materials is structured and transparent. As the glue that links fragmented sources of knowledge, traceability helps create, store, retrieve, transfer, and apply process knowledge in the

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software development organizations, as per Ramesh (2002) The ability to trace the development of educational resources ensures that these materials meet predefined standards and learning goals. A study by Dettmer (2016) notes that traceability in educational contexts is particularly valuable in managing the lifecycle of assessments, from their creation to their implementation and revision. It also improves the ability to provide meaningful feedback to learners, ensuring that assessment items are aligned with learning objectives and that changes to these items are well-documented.

B. User Experience in Assessment Development

According to Law, Shaik and Roto (2014), UX, as a recently established research area, is still haunted by the challenges of defining the scope of UX in general and operationalizing experiential qualities in particular. User experience (UX) is a critical factor in educational environments. a well-designed knowledge management system must not only provide functionality but also offer an intuitive and engaging experience for its users. This includes ensuring that assessments are clearly linked to learning outcomes and that users (both educators and students) can easily understand the relevance of each assessment item. Traceability enhances UX by providing transparency in how assessment items are developed, revised, and linked to learning outcomes. Students can benefit from receiving targeted feedback that relates to specific learning objectives, while educators can better track the performance of individual assessment items over time. As shared by Wohlrab et al (2020), traceability is crucial for many activities including monitoring the development progress, and proving compliance with standards. In practice, the use and maintenance of trace links are challenging as artifacts undergo constant change, and development takes place in distributed scenarios with multiple collaborating stakeholders.

III. Traceability Process Flow for Assessment Item Development

A. Overview of Process Flow

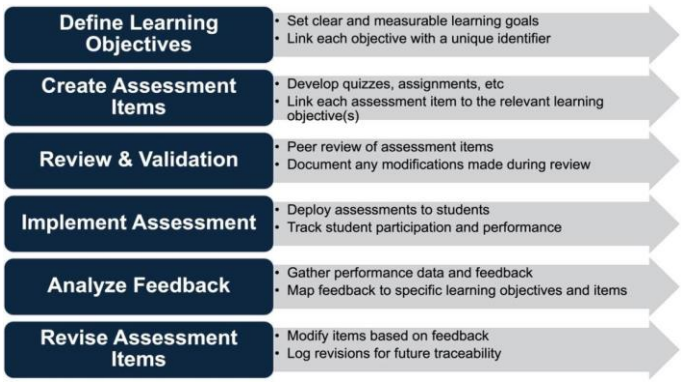
A well-structured traceability system for assessment development involves multiple steps. Each stage of the process, from the initial creation of assessment items to their implementation and feedback collection, is documented and traceable. The Figure 1 provides a high-level view of this process.

B. Stages of Traceability in Assessment

Step 1: Requirements Definition. The first stage in the traceability process is defining the requirements for the assessment items. This involves setting clear learning objectives that the assessments must align with. Traceability begins here by linking each assessment item to specific learning outcomes or educational goals.

Step 2: Assessment Item Creation. Once the learning objectives are defined, educators or content developers create the assessment items. These could include multiple-choice questions, essays, or practical tests. The traceability system ensures that each item is linked to the corresponding learning objective. At the same time, each item must be linked to a database of individual educator or content developer who has been involved in the content creation process.

Fig 1. Process flow for assessment itam development



Step 3: Review and Validation. After creation, assessment items go through a review process. Peer educators or experts review the items to ensure they are valid, fair, and appropriately challenging. Any changes made during this review are documented, maintaining the traceability of the item's lifecycle. It is important to ensure that the workflow captures detail of each individual reviewer in the process of creation of a single assessment item.

Step 4: Implementation. Once validated, the assessment items are implemented in the learning environment. Traceability systems track which students have taken the assessments, how they performed, and whether the items functioned as expected. It is equally important to record the use of each assessment item in different assessment module across different learning environment. The sequence of appearance of each item in a consolidated assessment may significantly influence the perceived difficulty of the item for the students.

Step 5: Feedback and Analysis. After students complete the assessments, their results are analyzed to provide feedback. Traceability systems link the feedback to the specific learning objectives and assessment items, allowing educators to identify patterns in performance and make data-driven decisions about content revisions. It may also lead to a dynamic model of composite difficulty index for the assessment module as a whole as well that of the individual assessment item.

Step 6: Item Revision. Based on the feedback, some assessment items may require revisions. All changes to the items are logged within the traceability system, ensuring that future assessments can be compared against past versions. Adherence to use of a traceability system, ensures a gradual alignment of achievement of assessment objectives with the learning objective of the corresponding learning module.

IV. Use Case: Applying Traceability To Assessment Development

A. Scenario Description

Project-Based Learning places an emphasis on students' practical solutions to a given situation. The focus is on strengthening students' ability to work together to come up with novel, useful, and tangible solutions to occasionally critical problems. Through problem-based learning, students take an active role in problem-solving while learning to ked eedback: presenting solutions to the business and improving them based on feedback.

We examine the case of a tertiary education institution that offers an online course in test preparation for admission to Business schools. The course has defined learning objectives, such as mastering basic quantitative method concepts and applying reasoning (verbal and analytical) to solve problems. The instructors want to ensure that the assessment items created for the course align with these objectives and provide consistent, targeted feedback to students through mock tests that are served to students at ana advanced stage of learning in the course.

B. Implementing Traceability

The institution implements a traceability system to track the development of assessment items across several stages:

Mapping Learning Objectives: The instructors define learning objectives (LO), such as "Understand basic quantitative methods in Plane Geometry" , “Apply Assertion-Conclusion reasoning for given statements” and "Apply sorting algorithms to datasets in table format." Each objective is assigned a unique identifier in the traceability system.

Creating Assessment Items: The educators create various assessment items, such as multiple-choice questions. Each item is linked to one or more learning objectives using the unique identifiers. It is also linked to the Mock test identifier where this item is used in a particular year.

Tracking Feedback: When students complete the assessments, their responses are analysed. The traceability system links student feedback to the specific learning objectives, providing insights into areas where students may need additional support. It also identifies the difficulty index of the item based on the number of students who attempted the item correctly as a percentage of those who attempted to answer the question.

Revising Items: After reviewing the feedback, the instructors decide to revise some of the assessment items to make them more aligned with the learning objectives. The changes are documented in the traceability system, allowing educators to track the evolution of each item over time.

C. Benefits of the System

The traceability system enhances the user experience by ensuring that students receive targeted feedback related to specific learning objectives. It also helps instructors maintain a clear understanding of how each assessment item aligns with course goals and whether any changes are necessary to improve the quality of the assessment.

Conclusion

Traceability in assessment item development provides substantial benefits in knowledge management environments. It enhances user experience by ensuring transparency, aligning formative assessments with learning objectives, and providing targeted feedback. The literature suggests that traceability systems, when effectively implemented, improve the quality and relevance of formative assessments, making them more effective tools for both educators and learners. In the context of rapidly evolving educational technologies, traceability will likely play an increasingly important role in curriculum development, helping institutions track the lifecycle of educational resources and ensure they meet the desired learning outcomes.

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