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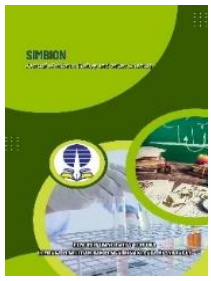

Designing Needs Analysis Instruments for Biology Teacher E-Training on Technology Integration

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A B S T R A CT

Effective technology integration in biology teaching requires competent educators, yet many face challenges, highlighting the need for relevant professional development. This paper details the foundational phase of a larger Research and Development (R&D) project aimed at developing and evaluating an e-training program for secondary biology teachers in Samarinda, Indonesia, via the Universitas Terbuka platform. Specifically, this work focuses on the initial design of instruments intended to understand teacher needs and context, aligning with the analysis stage of the Dick & Carey model. We describe the design process for three preliminary instruments: a survey questionnaire for mapping general needs, a semi-structured interview guide for in-depth qualitative insights, and an observation protocol for contextual analysis. Informed by literature on digital pedagogy and needs assessment principles, these instruments are crucial for ensuring the subsequent e-training program is contextually relevant and effectively targeted. Importantly, the instruments presented herein are initial designs and await validation. This paper contributes by outlining the systematic methodological process for developing these essential analysis tools, a critical first step before subsequent validation, data collection, and program development phases.

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INTRODUCTION

The contemporary educational landscape underscores the imperative for effective technology integration within subjects like biology to foster enhanced student learning, engagement, and preparation for a digitally-driven world (Ristanto et al., 2022). The use of technology can transform traditional biology teaching, sometimes perceived as static, by making abstract concepts more tangible and interactive, thereby deepening student understanding (Ristanto et al., 2022). Concurrently, there is a burgeoning demand for flexible professional development avenues, such as online teacher professional development (oTPD) and e-training, designed to equip biology educators with requisite digital competencies (Lund et al., 2024; Siswanto et al., 2018). This demand reflects a broader shift towards accommodating educators' diverse learning needs and schedules through online platforms, making continuous professional growth more attainable (Lund et al., 2024; Fischer et al., 2024). The

strategic use of technology in professional development aims to enhance skills and knowledge, offering advantages like increased accessibility and personalized learning pathways (Lund et al., 2024; Siswanto et al., 2018).

The efficacy of any e-training initiative, however, is fundamentally contingent upon a comprehensive understanding of the target audience's specific requirements, including their existing knowledge, technical skills, pedagogical beliefs, and contextual factors (Chigona & Chigona, 2022; Desimone, 2009). Professional development initiatives, particularly those focused on technology, that are not meticulously tailored to these needs are frequently perceived by teachers as ineffective and irrelevant (Tondeur et al., 2018). A robust needs analysis, therefore, acts as an indispensable foundational diagnostic tool, ensuring that e-training is precisely targeted, contextually relevant, and consequently, more likely to be effective (Beatty et al., 2020; Wolf & Stoodley, 2023). The design of needs analysis instruments must capture multifaceted requirements accurately to avoid misalignment and wasted resources (Tondeur et al., 2018).
This report delineates the foundational research and development (R&D) phase integral to the design of robust needs analysis instruments, specifically survey questionnaires and semi-structured interview guides for biology teacher e-training on technology integration. The Dick & Carey instructional design model serves as the principal theoretical framework guiding the needs and context analysis, ensuring a systematic approach (Akbulut, 2007; Burggraff, 2015). This report defines key concepts, outlines the systematic methodological process for developing these data collection tools, and aims to contribute to the fields of teacher professional development and educational technology (Beatty et al., 2020).

METHOD

This report synthesizes existing scholarly research to delineate a systematic methodological framework for the foundational research and development (R&D) phase of needs analysis instruments intended for biology teacher e-training on technology integration, following the structure requested (Patahuddin et al., 2022). The approach is rooted in established instructional design principles, primarily drawing from the Dick & Carey systems approach model (Akbulut, 2007; Branch, 2009; Burggraff, 2015) to structure the analysis of teacher needs and learning contexts, including identifying instructional goals, conducting instructional analysis, and analyzing learner characteristics and context (Akbulut, 2007; Burggraff, 2015). The design specifications for the proposed survey questionnaires and semi-structured interview guides are informed by a comprehensive review of best practices in educational research, encompassing survey methodology, qualitative inquiry, and instrument validation techniques (Beatty et al., 2020; Mthethwa-Kunene & Mncube, 2022; Wolf & Stoodley, 2023). The overarching R&D process advocated emphasizes an iterative cycle of design, expert review, pilot testing, and refinement to ensure instrument quality (Patahuddin et al., 2022; Robinson & Sebastian, 2020).

RESULT AND DISCUSSION

A. Conceptual Foundations and Needs Assessment Rationale

Online Teacher Professional Development (oTPD) and e-training utilize online platforms to deliver flexible and accessible learning experiences, enhancing educators' digital and pedagogical competencies (Lund et al., 2024; Siswanto et al., 2018). While often used interchangeably, e-training typically focuses on specific skill delivery, whereas oTPD encompasses broader professional growth, including pedagogical reflection and collaboration (Fischer et al., 2024; Usman, 2024). Technology integration in biology involves strategically using ICT to enrich teaching, making abstract concepts tangible and fostering inquiry-based learning (Kebritchi et al., 2023; Ristanto et al., 2022). Despite benefits like enhanced engagement and access to resources, challenges such as limited infrastructure, inadequate training, and negative teacher attitudes persist (Kebritchi et al., 2023; Ray & Zaveri, 2024). Teacher perceptions and confidence significantly mediate technology adoption, necessitating needs analysis instruments that capture not only technical skills but also attitudes, beliefs, and self-efficacy (Davis, 1989; Tondeur et al., 2018).

A robust needs assessment is paramount for ensuring that teacher e-training is relevant, tailored, and effective in changing practice (Chigona & Chigona, 2022; Desimone, 2009). It identifies the gap between

current and desired competencies, preventing program from being perceived as generic or disconnected (Tondeur et al., 2018). Lack of appropriate support for developing digital competence is a major obstacle to technology integration (Chigona & Chigona, 2022). Effective needs analysis must consider teachers' knowledge, constraints, interests, and context, as highlighted by differing priorities found between urban and rural teachers in Kenya (Chigona & Chigona, 2022). Furthermore, involving teachers in identifying their own needs fosters ownership and reduces resistance to change, making the needs assessment itself an empowering first step in professional development (Lawless & Pellegrino, 2007; Chigona & Chigona, 2022).

B. The Dick & Carey Model and Instrument Design

The Dick & Carey model provides a systematic framework for instructional design, viewing it as an interrelated system encompassing learners, instructors, materials, activities, delivery systems, and learning/performance environments (Akbulut, 2007; Burggraff, 2015). Its initial analysis phase, crucial for needs assessment, involves identifying instructional goals, conducting instructional analysis (breaking goals into subordinate skills), and analyzing learners (knowledge, skills, attitudes, motivation) and contexts (performance and learning environments) (Akbulut, 2007; Burggraff, 2015). This structured analysis, considering the interdependence of learner and context characteristics, informs the design of needs analysis instruments to accurately diagnose the full spectrum of requirements for effective technology integration (Beatty et al., 2020).

Effective survey design for assessing teacher needs requires anchoring in theoretical frameworks like TAM or TPACK, ensuring question clarity, using appropriate question types (e.g., Likert scales), maintaining logical flow, assuring confidentiality, and conducting rigorous pilot testing (Davis, 1989; Voogt et al., 2013; Beatty et al., 2020; Wolf & Stoodley, 2023). Key content areas for biology teacher surveys include demographics, current technology use (general and biology-specific), perceived ICT competencies (TPACK focus), attitudes/beliefs, perceived barriers, and PD preferences (Kebritchi et al., 2023; Davis, 1989; McNamara, 2024; Lund et al., 2024). Validation involves expert review for content validity and pilot testing for clarity and reliability (Robinson & Sebastian, 2020; Patahuddin et al., 2022). Contextualizing questions to specific biology teaching scenarios is vital for gathering authentic and actionable data (Ristanto et al., 2022; Kebritchi et al., 2023).

Semi-structured interviews complement surveys by providing in-depth qualitative insights into teachers' experiences, reasoning, challenges, and nuanced support needs (Mthethwa-Kunene & Mncube, 2022). Interview guides should feature open-ended questions sequenced logically, moving from general to specific topics (deMarrais et al., 2023). Key areas include detailed narratives of technology use, exploration of challenges and successes, specific support needs, visions for technology use, and affective dimensions (Mthethwa-Kunene & Mncube, 2022). Skilled interviewers use non-directive probes and establish rapport to encourage candid responses, especially regarding sensitive topics like skill gaps or anxieties (deMarrais et al., 2023). Ensuring trustworthiness through credibility (member checking, peer debriefing), transferability (thick description), dependability (audit trail), and confirmability (reflexivity, audit trail) is crucial (Shenton, 2004; Walden University, 2025).

The following table (Table 1, adapted from previous Table 2) compares the roles of surveys and interviews in this needs analysis.

Table 1: Comparison of Survey Questionnaires and Semi-Structured Interviews for Needs Analysis in Biology Teacher E-Training

Feature/Dimension of Comparison	Survey Questionnaires	Semi-Structured Interviews
Primary Purpose in Needs Analysis	Gather broad, quantifiable data on prevalence of needs, skills,	Gain in-depth, nuanced qualitative understanding of individual

	attitudes, resources across a larger population; identify general trends (Beatty et al., 2020).	experiences, reasoning, challenges, successes; explore the "why" and "how" (Mthethwa-Kunene & Mncube, 2022).
Type of Data Generated	Primarily quantitative (frequencies, means); limited qualitative (open-ended) (Wolf & Stoodley, 2023).	Primarily qualitative (rich text, quotes, narratives) (deMarrais et al., 2023).
Key Strengths	Efficient for large samples; anonymity; quantifiable data; identifies patterns (Nayak & Narayan, 2019).	Allows probing; uncovers unexpected insights; rich context; flexible; captures nuance (Galletta, 2013).
Key Limitations	Limited depth; restrictive options; potential misinterpretation; response rates (Nayak & Narayan, 2019).	Time-consuming; potential interviewer bias; not statistically generalizable; requires skilled interviewers (Galletta, 2013).
Examples of Information Best Gathered	Frequency of software use; self-rated proficiency; prevalence of barriers; preferred e-training formats (Ertmer et al., 2012).	Narratives of virtual lab use; exploration of tech anxiety/excitement; specific support needs; impact of school culture (Davis et al., 1989).

The subsequent table (Table 2, adapted from previous Table 3) outlines the design framework for these instruments.

Table 2: Design Framework for Needs Analysis Instruments for Biology Teacher E-Training

Instrument Component	**Survey Questionnaire**	**Semi-Structured Interview Guide**
Primary Purpose	Gather broad, quantifiable data on needs, skills, attitudes, resources, context; identify trends (Beatty et al., 2020).	Gain in-depth qualitative understanding of experiences, reasoning, challenges, successes; explore "why" & "how" (Mthethwa-Kunene & Mncube, 2022).
Key Content Areas/Themes (Examples)	- Demographics & context (Kebritchi et al., 2023) - Current tech use (Kebritchi et al., 2023) - ICT competencies/TPACK (McNamara, 2024) - Attitudes/beliefs (Davis, 1989) - Barriers (Kebritchi et al., 2023) - PD needs/preferences (Lund et al., 2024) - Access for PD (Fischer et al., 2024)	- Narratives of tech use (Mthethwa-Kunene & Mncube, 2022) - Challenges & strategies (Davis, 1989) - Successes/innovations (Mthethwa-Kunene & Mncube, 2022) - Specific support needs (Davis, 1989) - Visions for tech use (Davis, 1989) - Affective dimensions (Davis, 1989) - Perceived student impact (Davis, 1989)
Types of Questions/Probes	- Closed-ended (Likert, MCQs) (Beatty et al., 2020) - Limited open-ended (Beatty et	- Open-ended questions (deMarrais et al., 2023) - Non-directive probes (deMarrais

	al., 2020)	et al., 2023) - Directive probes (clarification) (deMarrais et al., 2023)
Validation/Trustworthiness	Expert review; Pilot testing (cognitive interviews); Reliability analysis (Cronbach's alpha) (Robinson & Sebastian, 2020; Wolf & Stoodley, 2023).	Expert review; Pilot interviews; Member checking; Peer debriefing; Audit trail; Reflexivity; Thick description (Amankwaa, 2016; Shenton, 2004).
Link to Dick & Carey Model (Analysis Phase)	Learner Analysis; Context Analysis; Entry Behaviors (Akbulut, 2007; Burggraff, 2015).	Learner Analysis; Context Analysis; Entry Behaviors (Akbulut, 2007; Burggraff, 2015).

C. Systematic Development and Validation Process

The development of needs analysis instruments follows a systematic R&D approach, involving iterative cycles of design, expert feedback, pilot testing, analysis, and refinement (Borg & Gall, 1983; Patahuddin et al., 2022). This process begins by defining objectives grounded in the Dick & Carey model's analysis phase and relevant literature (Akbulut, 2007; Patahuddin et al., 2022). Instrument drafts are then developed based on identified content areas and best practices (Beatty et al., 2020; deMarrais et al., 2023). Expert validation assesses content and face validity, clarity, and structure, guiding revisions (Robinson & Sebastian, 2020; Polit & Beck, 2006). Pilot testing with representative teachers identifies issues with clarity, timing, and feasibility, using methods like cognitive interviewing for surveys and practice runs for interviews (Wolf & Stoodley, 2023; Kvale, 2007). Pilot data analysis, including reliability checks for survey scales (e.g., Cronbach's alpha), informs final refinements before instrument finalization and administration protocol development (Robinson & Sebastian, 2020; Polit & Beck, 2006).

CONCLUSION

This report has outlined a systematic framework for designing needs analysis instruments—survey questionnaires and semi-structured interview guides—for biology teacher e-training on technology integration, grounded in the Dick & Carey instructional design model. The critical role of a thorough needs analysis in creating relevant and effective e-training has been underscored, emphasizing the need to understand not only skills but also teacher attitudes, beliefs, and contextual factors. The complementary strengths of surveys for breadth and interviews for depth were highlighted, alongside a rigorous R&D process involving expert validation and pilot testing to ensure instrument quality and trustworthiness.

The practical implication for e-training developers and school leaders is the importance of investing in this foundational needs analysis phase to design targeted and impactful professional development. For researchers, this work suggests avenues for investigating the long-term impact of needs-informed e-training and exploring optimal ways to translate needs analysis findings into personalized learning pathways. Ultimately, well-designed needs analysis instruments are fundamental to empowering biology teachers with the competencies needed for effective technology integration, thereby enhancing biology education quality and preparing students for a technologically intertwined future.

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