Testing Tablet Computers in Nursing Education: A Comprehensive Evaluation Framework

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Abstract **- Background:** Tablet Computers (TCs) and other mobile digital devices are rapidly changing the way we communicate and access information in our personal and professional lives. Scarce research exists regarding their effectiveness in promoting the learning of health professionals. This paper describes the evaluation framework used in a study to test TCs in a post-diploma baccalaureate nursing program in the Gulf Cooperation Council (GCC) state of Qatar.
Purpose: The evaluation framework was structured around 10 objectives designed to assess the impact of TC integration into the evidence-based practice (EBP) and reflective practice (RP) components of a scholarship course. Evaluation variables included perceptions of knowledge, confidence, comfort, satisfaction and technical skill before and after the 7-week TC implementation; students' usage patterns and attitudes about the usefulness of TCs in promoting their learning related to EBP and RP were also examined; in addition, students' views about the impact of TCs on the learning environment and their engagement in the learning process were sought.
Methods: A mixed method descriptive design was used to assess outcomes of interest. Qualitative methods (focus groups, participant observation, field notes and reflective journals) were used to capture subjective perspectives of TC users. Quantitative methods (pre-test/posttest, activity logs and skills labs) were used to assess change in knowledge, attitude and technical proficiency over time.
Results: The evaluation framework used to assess process and outcome variables in this study combined structural, philosophical, theoretical, pedagogical and methodological elements. These included the logic model, participatory action, theory-based course concepts, as well as a learning taxonomy involving cognitive, affective and psychomotor competencies.
Conclusion: The value of a comprehensive evaluation plan executed in tandem with TC implementation is highlighted.

Keywords: Tablet Computers; Evidence-Based Practice; Reflective Practice; Participatory Action Research; Program Evaluation

I. Introduction

Current educational curricula of health professionals reflect a movement toward digital environments [1- 4]. This trend coincides with the technology-intensive health sector transformations of the 21st century. The healthcare industry of the millennial era has been characterized by an explosion of new information, an exponential growth of electronic publications, the emergence of digitized health records and diagnostics, as well as widespread use of mobile technologies [1, 5-6]. Handheld digital devices and social media have revolutionized communications and information access within healthcare and all sectors of society. Consumers and providers alike expect immediate, efficient access to health services data to inform decision-making [7].

The assumption underlying this study is that the integration of information and communication technologies (ICTs), specifically mobile devices, into undergraduate education will help students develop competencies necessary to function effectively and efficiently in the current knowledge-based economy. Using mobile technologies in nursing education is both strategic and visionary given that millennials, born 1980-2003, have been immersed in technology since childhood [8]. Being "*connected*" to high-speed internet, wifi and social media, while sharing ideas via interactive communications, such as "tweets", texts, videos and photos, is the norm for this generation.

Teaching students who are already entrenched in technology requires that educators adapt teaching methods to ensure emerging graduates are prepared with requisite knowledge, skills and attitudes to meet the demands of technology-intensive work environments. The challenge of educators is to assist these digital natives [9-11] to combine their existing technological expertise with pedagogical and professional competencies so they can readily transfer these blended skills to the workplace.

To effectively captivate students' interest, capitalize on their technological expertise, maximize leadership capacity and promote innovative scholarship, educators must embrace a paradigm shift [12,13]. The impetus for this study was rooted in our desire to actively engage students in a participatory teaching-learning process evolving around contemporary *e*-learning and *m*-technologies. Our goal was to foster the development of competitive skills necessary to envision and lead future change.

II. Study Background & Context

Faculty at University of Calgary-Qatar (UCQ) in Qatar decided to integrate tablet computers (TCs) into classroom teaching. TCs are compact laptops or notebooks with convenient wifi connectivity, folding and rotation features that

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offer user flexibility in keyboarding, viewing and texting functions. New lightweight, user-friendly models with fast processing speed, high resolution screens, long battery life, diverse applications and efficient interfaces have led to rapid acceptance and increased use in clinical and classroom settings [2,3,7,14-15].

Seventy five TCs were purchased by the IT department at UCQ. Consultative discussion amongst teaching staff resulted in the decision to target the nursing scholarship course to test their use. The course includes an evidence-based practice (EBP) module which relies heavily on technology-oriented teaching-learning processes [16]. Students learn how to locate best available literature evidence using systematic online search strategies; they also develop skill in exploring different search engines, electronic websites and databases housing empirical data specific to healthcare questions or dilemmas. Literature indicates that mobile devices, such as smart phones and TCs, are being increasingly used by healthcare professionals as point of care decision supports [2-4, 17-20]. This evidence justified the fit of this course for our TC implementation and evaluation.

Reflective practice (RP) is another core module of the nursing scholarship course. Students are taught the principles and procedures of reflective journaling (RJ) and complete a written reflection describing one aspect of their learning in the course. We were confident that valuable subjective data would be generated by having students reflect on their experience in using the TC for course-related activities and assignments [21-22].

Because our goal was to engage students as co-researchers in the inquiry-discovery process and as collaborative partners in the teaching-learning process, we structured this study around a participatory action research (PAR) philosophy [23]. We reasoned that this approach would ensure students' input shaped planning, implementation and evaluation activities.

A. Study Purpose

Our purpose in introducing mobile technology into the classroom was to assess students' response to the TC as an adjunct to learning. We also wished to assess the impact of TCs on students' engagement in the learning process. Further, we wanted to assess students' attitudes, perceptions and satisfaction with the TC as a tool in enhancing their knowledge and skill competencies pertaining to EBP and RP. We hypothesized that integrating this mobile technological device with course content and related assignments would provide opportunity for abundant practice, a pre-requisite to developing confidence and mastery in TC use [24].

B. Research Question

The primary question of this study was: Do tablet computers (TCs) foster student learning of the principles and procedures of evidence-based practice (EBP) and/or reflective practice (RP)? Our specific focus of inquiry was structured around ten measurable objectives.

C. Objectives

- Assess students' *change in knowledge* related to tablet computers (TCs) following a 7-week experience using this mobile device.
- Assess students' *change in comfort, confidence, competence and satisfaction levels* with tablet computers (TCs) following a 7-week experience using this mobile device.
- Assess students' *change in technical proficiency* in tablet computer (TC) use following a 7-week experience using this mobile device.
- Describe usage patterns associated with TCs.
- Describe the extent to which students' perceive TCs are helpful in promoting learning related to EBP and RP.
- Identify enablers and barriers associated with TCs in fostering access to current, best evidence to inform clinical decision-making.
- Describe the extent to which students' perceive a personal TC is useful in promoting work efficiencies (e-reading, journaling, information access, decision support).
- Identify the critical success factors perceived to be of highest importance when integrating TCs for academic purposes in the classroom.
- Describe lessons learned following the introduction of TC into an undergraduate nursing scholarship course, specific to EBP, RP and wireless (Wifi) capacity on/off UCQ campus.
- Describe user perceptions of the impact of TCs on the quality of the learning environment and students' engagement in the learning process.

D. Design and Sampling

A mixed method, cross-sectional, descriptive design with convenience sampling was used to achieve study objectives. With the exception 1 Filipino and 5 Indian expatriate nurses, all study participants were Arab or non-Arab Moslems, with English as a second language. Gender mix included one 1 male and 73 females.

III. Evaluation Framework

The comprehensive model developed to evaluate TCs in the classroom is depicted in figure 1. The framework comprises 5 core elements (course components, learning activities, learning domains, monitoring processes, outcomes/outcome measures). It represents 5 dimensions of evaluation: philosophical, structural, pedagogical, methodological, and theoretical. Evidence informing the design of the model is described below to explain its genesis.

A. Philosophical Dimension – Participatory Action

The study was philosophically framed within a participatory action research (PAR) paradigm. PAR was relevant to the research question, the study context and the student population because of its focus on participant engagement, democratic processes and "collective self-reflective enquiry undertaken by participants" [23]. Investigators using PAR seek to understand local issues and identify practical solutions to social or educational practices. The data collection methods commonly used in PAR are participant observation, field notes and focus groups [25]. These seemed an appropriate fit with our desire to immerse students in a collaborative, inquiry-based experience aimed at assessing the usefulness of the TC as a teaching-learning tool for acquiring knowledge related to two theoretical course concepts, EBP and RP.

B. Structural Dimension – Logic Model

The logic model (LM) [27] provided the overarching structure to guide the TC evaluation. As an organizing structure, the LM offered an "*at-a-glance*" template to depict the course components (EBP and RP), teaching-learning activities (five tablet tasks), learning domains (cognitive, psychomotor, affective), monitoring processes (participant observation, field notes, focus groups), study outcomes (usage patterns; change in knowledge, attitude or technical proficiency; learning enablers/barriers) and evaluation methods used to assess variables of interest (pretests/posttests; skills lab; reflective journals; activity logs; satisfaction surveys). LMs graphically clarify the purpose of the project, the plausible linkages among project components and the underlying logic or causal assumptions. It provided a practical structure to show hypothesized relationships between the different evaluation components and to identify measurable outcomes pertaining to the TC learning tasks [28].

A literature search uncovered no empirical studies using the logic model to evaluate TCs in healthcare or beyond. Thus, our approach reflects a novel strategy to the appraisal of TCs in the classroom and our results contribute new knowledge to evaluation research.

C. Theoretical Dimension – Evidence-Based Practice (EBP)

EBP is an integral part of undergraduate and graduate nursing programs around the world [29]. The challenge of educators is to move beyond the rhetoric by helping students develop skills in accessing, evaluating and applying health science information to clinical problems. Whereas most baccalaureate students of the millennial generation possess the technical skills to manoeuvre in online environments, many find it challenging to locate, understand and critically appraise research evidence. Mastering and demonstrating the competencies of EBP is even more difficult for Arabic-speaking students because of the predominance of English language publications. This reinforces the need for systematically planned, culturally-appropriate instruction using varied teaching-learning approaches and guided mentorship. In the scholarship course, we used diverse strategies, including inquiry- and web-based discovery exercises, hands-on problem-solving, interactive dialogue and group collaboration to help students grasp theoretical principles and procedures of EBP.

The 6S hierarchy of preappraised evidence was a foundational part of the EBP module [30]. This hierarchical pyramid differentiates six levels of preappraised evidence. They are categorized as level 1 systems data, level 2 summaries, level 3 synopses of syntheses, level 4 syntheses, level 5 synopses of single studies, and level 6 individual studies. Preappraised evidence is data from secondary sources that has been evaluated and summarized by experts. It provides health professionals, who do not have strong critical appraisal or research skills, with the most current, high quality information to guide clinical decision-making [29, 30]. Students were taught how to access literature data from different levels of the 6S hierarchy and were expected to classify evidence into the 6 different levels. Evaluation procedures (TC skills lab) assessed students' ability to use the TC to navigate in different databases, locate best evidence related to a specified question and accurately classify literature. Besides using the TC to locate best available evidence, they had the option of using laptop and desktop computers and were asked to identify their preferred device for conducting literature searches, along with rationale.

Theoretical Dimension – Reflective Practice (RP)

Similar to EBP, RP is a form of inquiry aimed at improving clinical performance of health professionals. A reflective practitioner is one who engages in introspective and critical self-analysis for the purpose of answering specific questions. The focus of reflective inquiry is self-observation, a process whereby one subjectively examines personal experiences, perspectives and feelings [21]. Schools of nursing use journaling to encourage students to regularly engage in thoughtful, meaningful self-appraisal and to establish a pattern of lifelong reflective questioning [31].

The theoretical roots of reflective practice originate with philosophers John Dewey and Donald Schön who advanced the premise of thinking about learning, experience and feelings in an iterative manner [32]. RP in the nursing profession has been heavily influenced by Mezirow [33]. He espoused the notion that reflection, in the context of adult learning, involves the critique of taken for granted assumptions about a particular problem or problem-solving process. Mezirow believed that the deliberate appraisal and analysis associated with RP can lead to life-changing insights that explain, resolve or transform one's perspectives [34].

In the scholarship course, students were asked to reflect on their learning experience as TC users when writing their journal. The following suggestions were presented as prospective focus questions: did the TC help or hinder my learning of EBP; what factors enabled or impeded my ability to use the TC efficiently; what could have been done

differently to optimize the use of the TC as a teaching-learning adjunct; did the TC help me to engage in the learning process; did the TC influence the quality of the learning environment?

Our rationale for suggesting these questions as RJ targets evolved from literature that reports different perspectives of TC users in the health professions. The correlation between classroom TCs and learning environments / learning engagement has been examined in empirical studies [15, 35]; anecdotal accounts reflecting positive, negative and mixed experiences have been published [2-3, 20]; and an increasing body of conceptual literature is accumulating that summarizes user perspectives about lessons learned [2-3, 36, 37].

Analysis of narrative accounts obtained from RJs enabled us to summarize lessons learned from the TC implementation and evaluation. This informs future thinking about software and apps needed to foster TC use as an effective decision support. To our knowledge, no research to date has used RJs as a data collection method to capture subjective perspectives of TC users.

D. Pedagogical Dimension – Learning Activities

The pedagogical elements of the study evolved around a learning taxonomy comprising cognitive, psychomotor and affective domains [26]. This paradigm informed learning outcomes, along with the methods used to monitor and measure them.

Tablet tasks associated with EBP and RP were specified by the professor based on required learning competencies pertaining to the scholarship course. The tasks required students to apply and develop proficiency in varied TC functions. Each assignment challenged students' TC skills in different ways (Fig.1). Tablet tasks included reading e-text chapters, completing 3 EBP learning modules, exploring websites to locate preappraised evidence related to a specific research question, demonstrating a keynote presentation in a skills lab and typing a RJ.

Students' ability to complete these tablet tasks provided dual insights; namely, their technical skill in using the TC, as well as their cognitive understanding of core course content related to EBP and RP.

The approach taken to assign tablet tasks reflected a structured approach to TC use in the classroom [35, 38]. Integrating TCs into instructional activities in a directed, deliberate way enabled every student to tackle TC functions independently or with guidance. During classes and in their individual study time, students were encouraged to use the TC to take notes, read e-texts, browse the web, access pdf files, annotate documents, as well as retrieve, review and classify research papers from varied websites or electronic databases. Our goal was to immerse students in TC technology as much as possible to ensure a broad test of its functions.

An alternate, unstructured approach to TC use is described in the literature [39]. This method involves delivering course content using traditional methods, with students having flexible options to use or not use the TC as a learning adjunct in the classroom.

Research exploring pedagogical practices and classroom factors that optimize the benefits of TC, as well as those that act as obstacles is in its early stages [15, 35,38-39]. The goal to identify conclusive causal links between students' use of technological adjuncts in the classroom and learning outcomes is hampered by the reluctance or slow response of college educators to test and adapt new teaching approaches to meet the needs of digital learners [1, 13, 40]. Strategies recommended to promote change are those that we embedded in our research. They included: blending technology with teaching-learning processes, assigning resources to support technology-assisted learning and using a collaborative, inter-professional approach consisting of faculty from nursing, computer science, library science and English [1].

Pedagogical Dimension – Learning Domains (Cognitive, Psychomotor, Affective)

Learning in the cognitive domain is focused on knowledge acquisition and intellectual development [26]. These are assessed at six different levels: knowing (recall of factual information or principles); comprehending (describing the meaning of information); applying (transferring learned information to new situations); analyzing (breaking down information); synthesizing (aggregating information from multiple sources) and evaluating (judging the relevance/value of information).

Our TC evaluation pertaining to knowledge competencies centered on assessing the degree to which students integrated their knowledge of technology with the principles and systematic procedures of EBP. Successful retrieval of current, research data pertaining to a clinical problem challenges all 6 cognition levels. For instance, an electronic search for best available evidence requires knowledge of the information contained in different databases and an ability to predict appropriate data sources (recall). Planning an effective search strategy and identifying key search terms involves an understanding of the issues associated with the clinical question (comprehension). Screening citations and abstracts generated from the electronic search entails assessment as to whether the information applies to the clinical question (application). Classifying evidence according to the 6S hierarchy requires skill in distinguishing the features of the publication (analysis). Accurately summarizing results of the search involves aggregating information from different sources (synthesis). The process of locating current, best available evidence involves trial-and-error efforts. This, along with judging the quality of evidence and justifying its relevance to the question and context, are discriminative cognitive functions (evaluation).

Learning in the psychomotor or "skills" domain involves acquiring abilities to perform fine and gross motor movement. Psychomotor skill mastery is measured in terms of speed, precision and procedural technique within seven categories: perception (ability to use sensory cues); set (preparedness to act); guided response (actions are observed by another or follow specific criteria); mechanism (learned response

becomes habitual); complex (activity performed involves coordinated patterns and/or multiple movements); adaptation (ability to modify movements to meet different demands); and origination (creativity in developing new patterns in response to different situations) [41].

We evaluated psychomotor competencies by assessing students' technical skill in using the TC to locate, download and file literature. Using a formal skills lab, we observed their ability to navigate efficiently in different electronic websites and databases. We tested their proficiency in presenting aggregate information using the TC keynote App.

The affective domain is focused on acknowledging feelings, interests, values and attitudes associated with the learning experience [26]. There are five categories of affective learning, each specifying the degree of emotional responsiveness to a learning task. Categories include: receiving (attentiveness / listening to information presented); responding (active participation in learning processing); valuing (worth attached to the information / learning experience); organizing (prioritization of values pertaining to the learning process) and internalizing (values related to learning motivate and characterize learner behaviors) [42].

Literature data describing students' attitudes toward TC use in the classroom reflect evolving patterns over time. Common complaints associated with first-generation tablets included high cost, short battery life, difficulty opening, closing, and saving files, as well as problems synchronizing with main PC, difficulty with device functionality, poor screen quality, limited access to high speed internet in rural areas, and lack of IT support [15,36]. Some users of upgraded models continue to express concern about the high cost of hardware and apps, lack of user-friendly interfaces and the cumbersome on-screen keyboard [2, 7]. Others describe interactive and engaging learning environments, improved access to information and EBP decision supports, convenient portability, and audience response systems fostering active involvement in conferences as positive impacts of TCs [3,15,38]. Publications predominantly reflect observational studies and/or anecdotal perspectives associated with one-time pilot tests. This evidence informed our decisions about device selection for the study, as well as monitoring processes and IT supports.

E. Methodological Dimension – Monitoring Processes

Monitoring process variables associated with the TC study reflected our PAR philosophy. We believe the proactive, inclusive philosophy used to engage students throughout the TC implementation was one of the strengths. Students' responses to the assigned tablet tasks were assessed using participant observation and field notes. The research team member assigned as participant observer and field note scribe had a strong background in English for Academic Purposes (EAP); as such, she was to distinguish language from technical challenges that seemed to be impeding student learning.

Throughout the 7-week implementation period, 15-minute focus groups were held at the onset of each class. These provided an opportunity for ongoing student-faculty interaction and ensured TC user needs were addressed and supported. They also helped to create an atmosphere of collaborative problem-solving and dialogue amongst students.

Focus groups were co-facilitated by a student volunteer and research team member with expert knowledge of TCs. Dialogue centered on strategies deemed useful in promoting proficient use of the TC in relation to assigned tablet tasks. Consistent with other research [3,15,36-37], we kept focus questions simple in order to generate student responses that were specific and practical. (e.g. What hurdles, frustrations or challenges did you experience in completing the tablet task this week? What TC functions or features were helpful in enabling you to complete the assignment? What TC limitations or barriers did you experience in completing the assignment)?

Briefing notes summarizing the highlights of focus group discussions were prepared by the scribe and circulated to each student, thereby keeping everyone apprised of TC user issues.

Methodological Dimension – Outcomes Assessed

Outcome assessment targeted specific psychomotor, cognitive and affective domains. Outcome indicators included: (1) TC usage patterns; (2) change in TC knowledge, attitudes and/or technical skills; (3) lessons learned re: TC as a teaching-learning adjunct (4) enablers and barriers in fostering access to current, best evidence; (5) perceived helpfulness of TC in promoting learning related to EBP; (6) perceived usefulness in promoting work efficiencies (e-reading, journaling, information access, decision support).

Methodological Dimension – Measurement Methods

Evaluation measures used to assess outcomes of interest included: (1) pre-test/posttest surveys; (2) online satisfaction surveys (training session; TC features/functions; IT support); (3) EBP skills lab (designed to assess students' skill in searching, screening and classifying literature in the 6S hierarchy, as well as assembling aggregate findings into a creative presentation using a TC app; (4) TC activity log; (5) anecdotal notes describing user issues; (6) RJ summarizing attitudes, opinions, or feelings associated with the TC learning experience.

Overall, the diverse measures used to assess student perceptions, knowledge and skill proficiencies regarding the TC provided rich insights about the blending of technology with theory, research and practice.

IV. Data Analysis and Results

Because the focus of this paper described the study protocol and evaluation framework, data analysis procedures and results will be reported in another publication.

V. Implications - Practice, Education & Research

We have described the comprehensive evaluation framework used to assess process and outcome variables associated with the pilot implementation of TCs in an undergraduate nursing scholarship course. We have highlighted the philosophical, theoretical, pedagogical, structural and methodological dimensions to be considered when evaluating an innovative teaching-learning intervention in an academic setting.

We imagine that TCs will become the "*new wave*" technology in nursing education and practice. Results of our evaluation provide rich insights about TC user experiences specific to EBP, RP and the learning climate/engagement process. Valuable data pertaining to cognitive, affective and/or psychomotor learning were captured that inform nursing education, practice, research and policy.

VI: Conclusion

Accelerated growth of healthcare systems in the Gulf Cooperation Council (GCC) countries of the Middle East in the past decade has created great demand for health professionals with diverse competencies. The region is committed to investing in the education of its health human resources to position them as leaders in healthcare delivery. Besides having the capacity to adapt to rapid transformative change, the current knowledge economy requires health professionals to be reflective practitioners and to demonstrate efficient communication and information technology skills, as well as evidence-based thinking.

Even though TCs, may be one of the "*technologies of choice*" for digital natives, there is limited research evaluating their use in academic or service settings [2,3] and scarce evidence assessing if/how they promote learning, practice effectiveness or efficiencies [7]. Rigorous studies are needed to formally assess the utility and efficacy of these mobile devices amongst healthcare professionals in both academic and service environments. Pilot implementations, should be conceptualized and executed in tandem with a comprehensive evaluation plan, similar to the model described in this paper, to ensure the assessment of multidimensional variables.

VII: Ethics

Approval was obtained from the Conjoint Health Research Ethics Board (CHREB) University of Calgary.

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D. Nussbaumer is a public services librarian. Her graduate preparation in computer science, educational psychology, library and information science enabled her to help students use the iPad as a learning adjunct and to develop their skill in literature search strategies. Her research interest centers on exploring the link between interactive digital environments and information literacy.

CJ Davison is an electives instructor who teaches technology literacy courses. In this study she helped plan, load, distribute and orient students to the iPads. She also attended all classes to collect focus group data and provide technology support to students. She has an MA in Learning and Technology, with research interests in educational technology, mobile learning, transnational education and adult learning.

C. Symes is a nursing practice instructor. She was involved in all stages of this project, assuming a major role in classroom instruction, focus group facilitation and learning support for students related to tablet computers. Her professional interests include technology use in the classroom, nursing education, clinical simulation and acute care.

L. Li is the chief librarian overseeing the Learning Commons' operations. She is passionate about information technologies in higher education, with a specific interest in exploring how the two can be brought together to enhance the teaching-learning experience. Her role in the iPad project focused on providing instruction in information literacy skills in the context of evidence-based nursing using the iPad as the searching device. She also contributed to the project by acting as an evaluator during the skill labs with all other project team members.

J. Shimoda is an English for academic purposes instructor with extensive experience in primary and secondary language education in Japan. Her role in this project involved participant observation and recording field notes reflecting her observations of the teaching and learning processes employed during classes. Areas of professional interest include the development of specialized corpora, reading fluency and content and language integrated learning.

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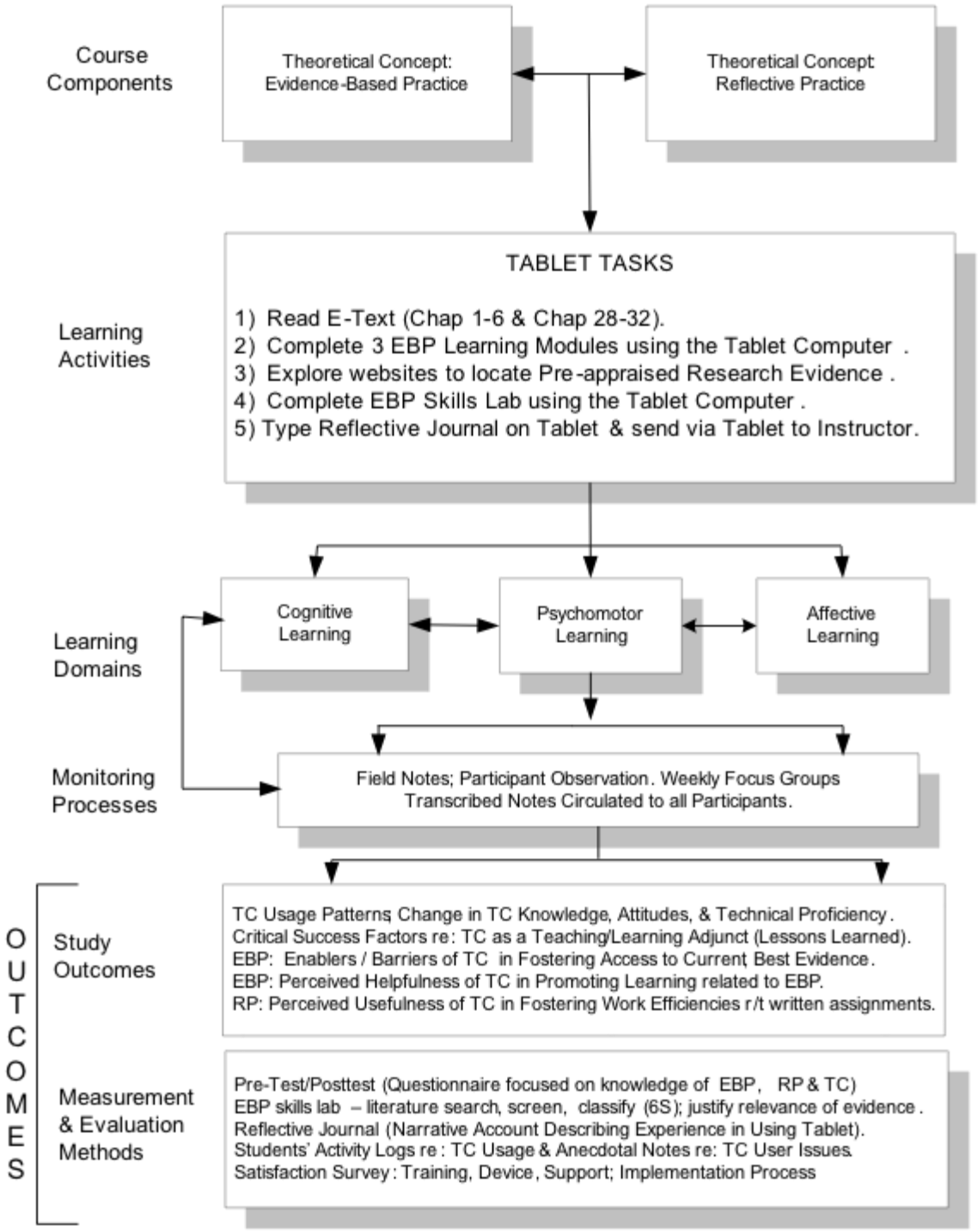

Figure 1: Tablet Computer (TC) Evaluation Framework