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INTERACTION EQUIVALENCY THEOREM: TOWARDS INTERACTION SUPPORT OF NON-TRADITIONAL DOCTORAL STUDENTS

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ABSTRACT

Aim/Purpose: This conceptual paper proposes interaction support based on the Interaction Equivalency Theorem (EQuiv) to support interaction for non-traditional doctoral students who have been identified as attrition risks.

Background: The master-apprentice form of doctoral education consists primarily of interaction with the supervisor for academic purposes. If this interaction is impaired, it may affect the ability to complete the dissertation due to insufficient knowledge, and it may also create a sense of isolation, which can lead to attrition. Nontraditional students have many characteristics that may inhibit this interaction such as being part-time or studying at a distance. Institutions have been urged to develop profiles of students at risk of dropping out based on past trends and offering intervention to students at risk. In conjunction with risk profiles, the EQuiv offers the potential to individually optimize interaction under time and resource constraints, with a view towards deep and meaningful learning.

Methodology: The paper is a conceptual paper using a systematic review of the literature, covering 50 years. Articles were sourced from various databases and journals.

Contribution: This article offers recommendations for improving interaction opportunities for nontraditional doctoral students in the master-apprentice form of doctoral education who are at risk of dropping out. It sheds a light on a distinct population whose needs are often overlooked. Additionally, the envisioned use of the EQuiv by organizations and academic departments is an expansion of its intended use by course designers. Additional original work is demonstrated by (a) the development of an EQuiv quality matrix to assess and rank the EQuiv liter-

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	ature, (b) a model of how the EQuiv might be employed to compensate for insufficient interaction, and (c) a representative model of socialization agents and knowledge transmission.
Findings	The doctoral experience and EQuiv literature have shortcomings regarding interaction support to non-traditional doctoral students. The literature on the doctoral experience does not capture the invisible problems of the nontraditional doctoral student who is under the master-apprentice form of doctoral education. Although institutions are urged to develop risk profiles based on characteristics of students who have dropped out, it still does not capture this specific group of students. Additionally, the socialization requirements of traditional doctoral students under the master-apprentice system are unclear, so the requirements of nontraditional doctoral students under this system are also not specified. Most EQuiv research does not pay attention to the cautions of Anderson (2003a), so the literature is based on situations that do not reflect the intent of the EQuiv. However, it is proposed that the EQuiv could be used as a substitution or augmenting of the S2T interaction in the master-apprentice model.
Recommendations for Practitioners	The proposed recommendations might assist practitioners in developing a risk identification process to support non-traditional doctoral students at risk within cost and time constraints for both students and departments.
Recommendation for Researchers	An empirical study of nontraditional doctoral student interaction experiences and requirements should be conducted, followed by an analysis of the interactions in the EQuiv. Additionally, the role of socialization of nontraditional doctoral students in the master-apprentice form of education should be explored. Furthermore, a literature review on various risk profiles might be of use to institutions wishing to develop preliminary profiles. Further research on the Interaction Equivalency Theorem is proposed. The EQuiv in its current form has been largely confined to the distance education discipline, mostly focusing on structured courses. The article enlarges the scope of the theory to also contribute to the field of doctoral education. Further research could focus on exploring the applicability of interaction preferences, substitutability and the strength of the interactions with this cohort of students. An adaptation of the EQuiv might assist practitioners in developing a risk identification process to support non-traditional doctoral students at risk within cost and time constraints.
Impact on Society	Support to non-traditional doctoral students in other countries may improve if the interaction is optimized, which in turn may affect persistence.
Future Research	Exploration of management models in support of doctoral student interaction.
Keywords	doctoral education, persistence, interaction equivalency theorem, part-time non-traditional students

INTRODUCTION AND BACKGROUND

Although not generally depicted as such, doctoral learning is regarded by some as a form of distance education, sharing its attributes of distance and autonomy. Additionally, doctoral students also experience some advantages and disadvantages in common with distance education students (Aghaee et al., 2016; Kozar, Lum, & Benson, 2014). As an example, a sense of isolation is held in common (Ali & Kohun, 2006; Lovitts, 2001; Tinto, 1975). High attrition rates are also shared; distance education

student attrition rates are 10-20% higher than for classroom-based programs, while doctoral students may experience attrition rates as high as 70%, depending on the discipline, program, and institution (Angelino, Williams, & Natvig, 2007; Bair & Haworth, 1999; Bowen & Rudenstine, 1992; Lovitts, 2001; Rovai, 2002; Spaulding & Rockinson-Szapkiw, 2012).

There are numerous factors in doctoral persistence; among them is the extent and quality of student-supervisor contact (Bair & Haworth, 1999, p. 13). In the *social cognitive theory*, knowledge and learning are obtained within a specific context, through interaction with others (Bandura, 2001). The student-supervisor interaction helps to socialize the student to the academic environment and to construct the knowledge needed to become an independent scholar (Lovitts, 2001). Traditional on-campus students have the maximum potential for doctoral learning (and socialization) through interaction with peers and supervisors (Gardner & Gopaul, 2012; Kozar et al., 2014). They also benefit most from vicarious learning, which is a component of doctoral self-efficacy. In vicarious learning, doctoral students observe how others perform research and manage time, and they can determine progress as compared to others (Kozar et al., 2014). Traditional students have the greatest potential for vicarious learning due to contact opportunities with peers and experts, while off-campus students have the least potential if they have no contact opportunities, plus the risk of isolation is a possibility (Kozar et al., 2014). Since many non-traditional doctoral students are self-funded, part-time working adults with other obligations (Offerman, 2011), they have even fewer opportunities for such contact.

Various theories have been developed in the distance education literature to address interaction support challenges. One group of theories refers to *equivalency,* which pertains to the equal value of learning experiences for distance and campus-based students. These learning experiences must be equivalent, but not necessarily identical. Also, the learning events and experiences should be applied appropriately to the situation and student (i.e., one method does not fit all). Additionally, students are defined by the course, not the location, and equivalency of outcomes is predicated by the equivalency of learning experiences (Simonson, Schlosser, & Hanson, 1999). Therefore, the needs of the students must be balanced about expected outcomes. The equivalency of dissimilar distance education and classroom instruction (CI) outcomes was later validated through numerous studies and a DE literature meta-analysis (Bernard et al., 2004; Simonson, 1999). One such theory is the Interaction Equivalency Theorem (EQuiv) (Anderson, 2003a).

The Interaction Equivalency Theorem pertains to the *equivalency of interactions* of students with other students and content if they are of sufficient strength. The theorem states that only one strong form of interaction is needed for deep learning, but if more interaction types are needed, they would likely incur cost and time penalties (Anderson, 2003a). However, the EQuiv has not been fully explored within its constraints, nor has it been theoretically addressed at the doctoral level, so its applicability is yet to be determined for the instance of non-traditional doctoral students. Moreover, the doctoral student experience literature contains scant research on non-traditional students, who traditionally have less time for studies (Gardner & Gopaul, 2012; Pifer & Baker, 2016; Zahl, 2015).

This conceptual article is situated in the doctoral experience literature. A systematic review was conducted to answer the research question: 'How can the EQuiv be used to enhance interaction opportunities of non-traditional doctoral students?' After an overview of the methodology, an overview is provided on non-traditional doctoral students, followed by the importance of interaction in distance education and doctoral education. Next, the EQuiv is explained, along with its processes and moderating factors and current empirical research. Thereafter, the findings and recommendations for interaction support of non-traditional doctoral students are discussed.

METHODOLOGY

This conceptual article extends the use of the Interaction Equivalency Theorem to support the interaction requirements of nontraditional doctoral students under the master-apprentice form of doctoral education. It uses a form of systematic review developed by Khan, Kunz, Kleijnen and Nantes,

(2003). The steps are as follows: (a) framing questions for a review; (b) identifying relevant work, (c) assessing the quality of studies;(d) summarizing the evidence, and (e) interpreting the findings.

Framing Questions for a Review

The research question of the article is "*How can the EQuiv be used to enhance interaction opportunities of non-traditional doctoral student*s?" In order to respond to this question, information was needed to understand the doctoral experience of non-traditional doctoral students following a master-apprentice model. Various keywords were identified: master-apprentice, persistence, attrition, dropout, distance education, non-traditonal students, doctoral education, doctoral experience, and doctoral persistence.

Further information was also needed on the Interaction Equivalency Theorem and keywords used were Interaction Equivalency Theorem, equivalency, and interaction equivalency. Due to the scarcity of the literature, an inclusive set of empirical literature on the EQuiv was used to obtain insight into the research question.

Identifying Relevant Work

After establishing the research question, an extensive review was conducted of academic databases such as ProQuest, ERIC, Taylor & Francis, Springerlink, and Google Scholar. Software and web applications used were Mendeley and Endnote, and to a lesser extent, Qiqqa. Articles were downloaded in pdf format and incorporated in a Mendeley database of more than 1046 articles in a 50-year range due to the essentiality of some works, e.g., Bandura and Tinto. The range in age of articles is an important consideration due to the uniqueness of the subject, the scarcity of literature, and theoretical and historical considerations. The journals reviewed included the following: American Journal of Distance Education, European Journal of Education, European Journal of Open, Distance and E-Learning, Higher Education, Higher Education in Europe, Higher Education Policy, Higher Education Research and Development, Innovations in Education and Teaching International, International Journal of Doctoral Studies, New Directions for Higher Education, Online Journal of Distance Learning Administration, Research in Higher Education, South African Journal of Higher Education, Studies in Higher Education, The International Review of Research in Open and Distributed Learning and The Journal of Higher Education.

Articles were of special interest concerning doctoral education under the U.K. method of study, the Interaction Equivalency Theorem (EQuiv), doctoral interaction, non-traditional students, and doctoral persistence. Also, due to the theoretical aspects of the research, pertinent and historical information has been included. Regarding the subject area, the set includes interaction requirements leading to persistence of non-traditional doctoral students in traditional doctoral master-apprentice programs. However, those articles that contained some of the required elements, such as interaction and distance education or doctoral education and persistence, were reviewed but not necessarily included in the article. The article itself extends to the following four boundaries: firstly, the dissertation writing stage of doctoral education, or students in the master-apprentice model of doctoral education, secondly doctoral education program management, thirdly non-traditional students, and lastly the doctoral student experience. Articles that were excluded included articles that were not peer-reviewed, were from a predatory journal, or only mentioned the EQuiv in passing.

Assessing the Quality of EQuiv Studies

Although these qualities are subjective, Table 1 is a compilation that is based on a longstanding familiarity with the EQuiv literature, along with some considerations from Miyazoe and Anderson (2010b). Although these criteria are an a priori phenomenon, the criteria represent the methodology for selecting and assessing the current EQuiv empiric literature. The criteria are also subjective, since they are representative of an ideal that has been formulated in the preliminary research. However,

they can be used to rank EQuiv studies in terms of overall quality if numeric scores are assigned to each category. The following quality categories (Table 1) have been formulated based on a similar approach by Khan et al. (2003):

Table 1: EQuiv Quality Matrix

Quality Categories	**High Quality (3 Points)**	**Moderate Quality (2 Points)**	**Preliminary Quality (1 Point)**
Understanding of Theorem	The intent of the theorem is completely understood and applied, and corollaries have been considered	The theorem is understood and applied	The theorem is misunderstood or misapplied
Number of interactions in design	All three interactions are addressed	Two interactions addressed	Only one interaction addressed
Substitutability (if in design)	One or more interactions are substituted for another and adequately explained	One or more interactions are substituted for another but not explained	Substitutability in design but not addressed
Interaction Strength (if in design)	Strength of interaction is in design and correlates to outcome	Strength of interaction is in design and is somewhat correlated to outcome	Strength of interaction is in design, but not addressed
Cost and Time in relation to adding interaction types (if in design)	Interactions were added and cost and time were well addressed	Interactions were added but cost and time were addressed	Interactions were added but cost and time were not addressed
Approach to learning considered in research design (e.g., constructivist)	Design of research considers and references approach to learning	Approach to learning mentioned but not addressed in design	Approach to learning not addressed nor built into design
Reference to Theorem	Theorem is designed into the research	Theorem is addressed in the research	Theorem is only cited or not mentioned in the research
Results	Results are comprehensive and well explained	Results are adequately explained	Results are poorly explained or sparse
Recommendations	Recommendations are substantive	Recommendations are few or non-substantive	No recommendations made
Originality	Work is substantive addition to body of knowledge or shows great originality in some aspect of the research	Work is similar to other studies but has some original worth	Work exhibits minimal originality

Summarizing the Evidence and Interpreting the Findings

As indicated by Khan, et al. (2003) it is difficult to summarize the results of empiric studies of varying degrees of quality and different research designs. However, the final steps of summarizing the evidence and interpreting the findings will be addressed in the appropriate sections.

Findings

The findings start with a review of non-traditional doctoral students, followed by interaction requirements in general and doctoral students, and lastly a review of the EQuiv.

Non-traditional Doctoral Students

The traditional doctoral program was developed for a historically small cadre of privileged males who were prequalified and predestined to succeed in doctoral programs (Jamieson & Naidoo, 2007; Johnson, Lee, & Green, 2000; Naidoo, 2015). Also, as compared to educational approaches at lower levels, doctoral education is individualized and unstructured (Gardner, 2009). However, students who are not single, young, white males who study on campus full time are marginalized by the prevailing academic culture, which is characterized by autonomy and independence but veers toward neglect (McAlpine, Paulson, Gonsalves, & Jazvac-Martek, 2012). These non-traditional students might be one or more of the following descriptors: older, part-time, married, female, fully employed, self-financed, and off-campus. Students from other cultures, countries, races and social classes may also be deemed non-traditional (Yeatman, 1998, as cited in Naidoo, 2015; Offerman, 2011). Anecdotal evidence suggests that the attrition rates of non-traditional students exceed those of traditional students (Bean & Metzner, 1985; Cotton, Nash, & Kneale, 2017). As examples, students in distance-based doctoral programs have attrition rates that are 10% to 20% higher (Terrell, Snyder, Dringus, & Maddrey, 2012). Some studies refer to a significantly higher attrition rate for self-financed individuals (Bair & Haworth, 1999; Bowen & Rudenstine, 1992).

Although the number of non-traditional students is increasing due to the global massification of Higher Education (HE) (Servage, 2009, as cited in Jamieson & Naidoo, 2007), studies of doctoral attrition do not usually reflect variations in demographics and characteristics to the needed extent, which allows this problem to remain unnoticed, unverified, and unresolved. As an example, numerous studies indicate that time to degree is negatively associated with persistence, but part-time status is not a consideration in many of seminal works such as Bowen and Rudenstine (1992) and Bair and Haworth (1999). Therefore, academic structures continue to be based on the traditional student model, assuming full student social and academic engagement, without regard to factors that may affect persistence in non-traditional students (Barron, 2014)

The extant literature offers a scant distinction between traditional and non-traditional doctoral students in the analysis and interpretation of data (Naidoo, 2015). Typically, studies of the doctoral student experience may include some descriptors (e.g., off-campus and part-time) which allow some inferences to be made on students possessing these traits, but any possible intersectionality of traits cannot be captured, since non-traditional students are seldom separately identified as such in national surveys (John & Denicolo, 2013). One partial exception is a longitudinal study of doctoral completions, which notes that the part-time student profile has less of the characteristics associated with success. These characteristics are as follows: (a) financial support, (b) overseas origin, (c) under 30, (d) first class honors, (e) natural sciences and related subjects (HEFCE, 2005).

These factors often limit the participation of non-traditional students (Cotton et al., 2017). They experience barriers to socialization (Naidoo, 2015); structural impediments, negative interactions, and feelings of otherness (Gilmore, Wofford, & Maher, 2016); a perception of being treated less preferentially than traditional students (Zahl, 2015); a longer time to completion (Earl-Novell, 2006); and perceptions of not having the same opportunities as peers (Pifer & Baker, 2016; Weidman, Twale, &

Stein, 2001). Cultural examples of barriers include first-generation students not being prepared to interact with faculty members in the way that is needed and expected (Padgett as cited in Cole & Griffin, 2013) and international students being reticent to interact with faculty (Weidman & Stein, 2003). Moreover, the concept of non-traditional student withdrawal is often described within social and cultural capital constructs (Cotton et al., 2017).

Although traditional doctoral programs are built around the prequalified traditional student, non-traditional doctoral students are not always qualified to persist (Jamieson & Naidoo, 2007). While information about non-traditional doctoral student interaction is relatively scarce, non-traditional undergraduate students are more likely to experience interaction with supervisors and peers that is less intense and of shorter duration than traditional counterparts (Bean & Metzner, 1985). Since supervisors (and to some extent, peers) socialize students in the traditional academic structure, non-traditional doctoral students are, therefore, less enculturated with organizational values as compared to traditional students (Lovitts, 2001).

The doctoral attrition literature affirms the importance of students becoming members of the scholarly community (which includes the supervisor, peers, and the department, etc.) and of socialization to this community (Devos et al., 2017). A review and synthesis of the doctoral attrition literature over ten years (approx. 2005-2015) revealed that the most common factors in attrition models and studies were the amount of academic and social integration and the quality of institutional experience, which includes interaction with faculty and peers (Aljohani, 2016a). Common recommendations for improvement are to identify at-risk students and to provide interventions that provide for departmental academic and social integration (Aljohani, 2016b; Cloete, Mouton, & Sheppard, 2015).

Development of risk profiles

The improvement of interaction opportunities for students at risk would assist with academic and social integration, and it is a logical intervention for non-traditional students having constraints. Studies that attempt to identify risk profiles and interaction support methods are not in abundant supply, but a few examples exist. Ali and Kohun (2009) developed risk factors to identify cultural isolation in a study of part-time doctoral students at a distance based program at one U.S. university. The criteria were based on student performance (e.g., attendance, milestone dates, and grades) and events within the frequent residencies (e.g., staying at the same hostel, relationships with cohort members, and lateness to class). The researchers discovered performance issues in the 18 students who were identified as being isolated. Since this program is very regimented, recommendations included possible program modification (Ali & Kohun, 2009). In another study (Peltonen, Vekkaila, Rautio, Haverinen, & Pyhältö, 2017), a doctoral experience survey was used to develop social support profiles based on variations in research community and supervisory support in a group of predominantly full-time doctoral students at a Finnish university. Although no individual student profiles were developed, students deemed to have inadequate support were more likely to consider dropping out. Unfortunately, the study did not measure part-time versus full-time students (although 46% of the students were part-time), nor was age a factor; although 53. 5% were under 35; ages ranged from 25 to over 50. Recommendations were to identify students at risk early, and to develop a means to assist with support.

The identification of non-traditional doctoral students at risk for attrition with the aim of improving interaction opportunities would assist with academic and social integration, and it is a logical intervention for non-traditional students having interaction constraints

Importance of Interaction

Interaction is a well-regarded component of education, it promotes effective learning, and contributes to motivation and persistence (Wang, Chen, & Anderson, 2014). For the purposes of this article, interaction is defined as "communication between the two major types of actors (human and non-human) in modern distance education" (Anderson, 2003b, p. 130) or, alternately, engagement in

learning (Wanstreet, 2006). In every educational setting, there are four components: (a) a teacher, (b) students, (c) a way to communicate, and (d) something to be learned (Simonson et al., 1999). The purpose of interaction in doctoral learning is to transmit knowledge, which is accomplished through socialization. Socialization is important to the dissemination of informal knowledge of the field, discipline and practice (Gopaul, 2011).

Socialization is the process of becoming a member of a specific group, including its particular values, attitudes, and knowledge (Gopaul, 2011). The socialization framework remains the most frequently used orientation for doctoral education; a considerable amount of the literature focuses on the socialization of doctoral students and to the various relationship roles during research (Gardner, 2010; Golde, 2000; Gopaul, 2011). The formal (cognitive) requirements of the professional role are contained in explicit departmental academic documents and culminate with the conferring of the academic degree. However, the informal (affective) normative aspects of the doctoral role are only implied and are learned informally through the interaction of the student with faculty and peers (Weidman & Stein, 2003).

Figure 1 is depiction of doctoral knowledge requirements by socialization source, formality, and level. At the macro level (domain), doctoral students formally learn domain level facts, concepts and theories from literature (Lovitts, 2008, p. 305, adapted by the authors). At the meso level (discipline and field), the department issues program requirements, defines norms, and sets forth policies for completion. At the micro level (practice), the student learns the doctoral practice through informal interaction with and observation of individuals. Both formal and informal knowledge are influenced by the social environment (Lovitts, 2005).

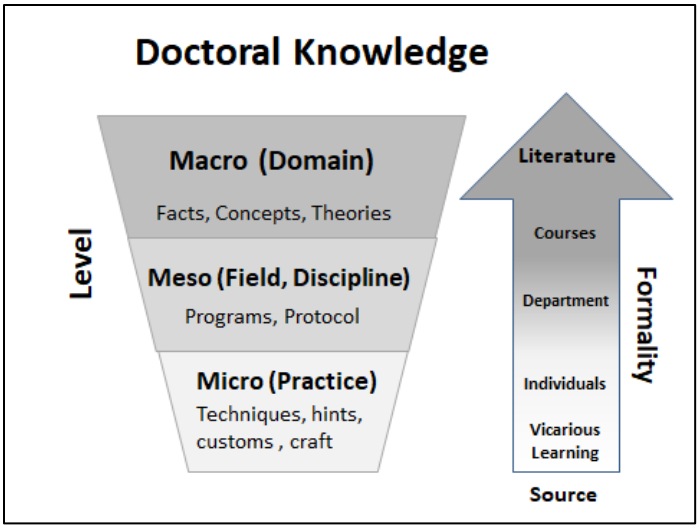

Figure 1. Doctoral Knowledge Levels

In doctoral education, formal knowledge of the domain is acquired before and while writing the dissertation (Lovitts, 2001). However, it is also very important for doctoral students to understand how the domain relates to the field (Sternberg & Lubart, 1995, as cited in Lovitts, 2008). Although domain knowledge is acquired primarily through the literature, some domain practices (e.g., methodology) are particular to the domain. As an example, students in the natural sciences domain are not expected to perform data analysis themselves but rely on data specialists, while in the domain of educational sciences, students perform their own analysis (Lepp, Remmik, Leijen, & Leijen, 2016).

Discipline knowledge consists of three stages: (a) understanding program objectives, (b) acquiring explicit core disciplinary knowledge and implicit disciplinary role expectations, and (c) adding to the literature of the discipline through the creation of new knowledge (Maher, Feldon, Timmerman, & Chao, 2013). However, there is only an implied relationship between discipline knowledge and its practice,

and few organizational policies exist as to how discipline knowledge is transmitted (Weidman & Stein, 2003). Although undergraduate education is presented monolithically, doctoral education practices are likely to differ by academic discipline (Gardner, 2009).

Despite doctoral students being well versed in a given discipline, they are still considered to be novices concerning the doctoral *practice* (Bargar & Duncan, 1982, as cited in Lovitts, 2008). The new scholar-apprentice must learn arcane, unique, and tacit doctoral customs and methods in the process of evolving from doctoral student to doctoral graduate (Burnett, 1999; Kiley, 2015). The doctoral practice is learned through informal networks, activities, and contacts with peers and academics (Tinto, 1975, as cited in Pather & Chetty, 2016).

The various interactions also help the student to make sense of the environment, to learn from others, and to see a way ahead towards dissertation completion. This sense-making forms both global and local cognitive maps towards the desired objective. The global map equates to the entire doctoral process (largely informed by the discipline), while local maps are gleaned from tacit information from supervisors and peers about departmental preferences, practices, and politics (Lovitts, 2001). A well-constructed cognitive map allows the doctoral student to anticipate and negotiate a highly complex and ambiguous environment, while the lack of a cognitive map contributes to failure (Ali & Kohun, 2007; Lovitts, 2001). Insufficient or improper socialization also contributes to the decision to depart from studies. If students cannot integrate into academic and social systems, it affects their goals and commitments and is predictive of a decision to depart although social integration is not essential to persistence (Tinto, 1975).

Interaction issues affecting doctoral studies

In higher education (HE), interaction is often categorized into interaction with faculty members, interaction with students in the same program, and interaction with the academic environment (Bragg,1976, as cited in Gardner & Gopaul, 2012). These categories correspond to three interaction issues that may have negative effects on the process and quality of doctoral studies: (a) insufficient supervision, (b) insufficient peer communication, and (c) insufficient information about the doctoral program (Aghaee et al., 2016). These issues are discussed in the appropriate categories.

Interaction with Supervisors. The student-supervisor interaction is considered to be the defining methodology of the master-apprenticeship model (Shulman, 2005, as cited in Flores, 2011), and it is the principal means of learning the doctoral craft at the dissertation stage. As compared to previous levels of learning, interaction with faculty is predominant, while interaction with peers is somewhat lessened (Sherlock & Morris, 1967, as cited in Lovitts, 2001). This disassociation affects the ability to form the cognitive map concerning the entire doctoral process, so the student is even more dependent on the supervisor for this support (Lovitts, 2001). However, because this relationship is considered to be private (and unique), supervision quality is sometimes distressingly variable (Barnes & Austin, 2009; McAlpine, 2013).

The literature is rife with issues such as supervisors being too busy (Bair & Haworth, 1999; Grossman, 2016); being unavailable (Bair & Haworth, 1999; Zahl, 2015); departing the position or organization (Wisker & Robinson, 2013); being abusive (Lovitts, 2001); bullying the student (Morris, 2011) not being intellectually invested (Bair & Haworth, 1999; McAlpine, 2013); not being interested (Bair & Haworth, 1999); providing advising that is insufficient or incorrect (Bair & Haworth, 1999); insufficient supervisory attention and guidance with the dissertation (Tucker, Gottlieb, & Pease, 1964, as cited in Allan & Dory, 2001), and having personality conflicts and poor supervisory relationships (Allan & Dory, 2001; Bair & Haworth, 1999).

The frequency of supervision contributes to a reduced attrition risk, while infrequent or inadequate supervision creates the opposite effect (Cornér, Löfström, & Pyhältö, 2017; Lovitts, 2001). In a survey of the doctoral student experience of Swedish students, supervisory input was found to be less frequent for students writing a monograph (as compared to article-based dissertations), part-time

students, and students in prolonged studies (Cornér et al., 2017). Although the literature in large part confirms the desirability of supervisor support for doctoral completion (Bair & Haworth, 1999; Lovitts, 2001; Spaulding & Rockinson-Szapkiw, 2012), it is not unanimous. In a study of the Canadian and U.K. doctoral experience, it was observed that although supervisors were important to doctoral students, they were not the most important aspect of the doctoral experience (McAlpine, 2013). Some doctoral students persist despite fraught relationships with or minimal support from supervisors (Devos et al., 2017). Despite these circumstances, one study found that students who persist in these circumstances are likely to possess a surfeit of self-sufficiency and great perseverance (Schulze, 2016).

Interaction with Other Students. Interaction with peers is common to many successful doctoral students. Peers are said to reduce feelings of isolation (Ali & Kohun, 2006; Lovitts, 2001), to contribute to learning (Pifer & Baker, 2016), to enhance the doctoral experience (Jairam & Kahl, 2012), to provide confirmation when working with peers in collaborative assignments (Garrison & Shale,1990, as cited in Anderson, 2003a). Others mention peer support being import to doctoral socialization (M. Jones, 2013). Furthermore, interaction with peers is found more often in successful graduates (Bair & Haworth, 1999). However, some indicate this interaction has a secondary role, so it is not a primary factor in doctoral attrition since persistence is shaped more by the supervisor than by others (Bair & Haworth, 1999; Golde, 2005; Tinto, 1993). The absence of peers is not a source of attrition decisions (Devos et al., 2017; Lovitts, 2001; Zahl, 2015), nor does the lack of peer support contribute directly to attrition (Bair & Haworth, 1999; Tinto, 1993).

Reasons for this dichotomy may be found in the structure and type of doctoral programs. Peer relationships may appear to be important in the first two phases of the three-stage U. S. style doctoral program; but in the last stage, students must transition away from peer relationships to work in isolation on the dissertation. This transition to independence is often upsetting since it is at odds with relationship-building found in earlier phases (Gardner, 2008). Moreover, the abrupt departure from the familiar classroom setting with its structured approach and social and academic interactions with supervisors and peers is an isolating experience (Mah,1986, as cited in Bair & Haworth, 1999). Although the role of peers in U.S. style doctoral programs has been addressed, it has not been sufficiently parsed out in the single-phase Master-Apprentice doctoral method, since most of the literature in doctoral studies journals is of U.S. origin (M. Jones, 2013). Since the U.K.-style doctoral programs have only a dissertation phase, Nerad (2012) advocates for the addition of varied types of communities of practice to these doctoral programs, so that students may learn to become socially adept when engaged in more global efforts versus graduating as a solitary academic in a given discipline. This recommendation is corroborated by other studies that advocate the addition of peers during the dissertation stage (Spaulding & Rockinson-Szapkiw, 2012), some advocating specifically for peer writing groups (Grossman, 2016; Hopwood, 2010; Walker & Yoon, 2017). In other words, peers could be an additive to the dissertation writing stage in a doctoral program if the pedagogical approach and outcome are changed.

Interaction with Structures of the Academic Setting. The lack of information has been described as an endemic issue in the doctoral experience (McAlpine et al., 2012). Students mention being frustrated and confused about the overall graduate student experience, particularly concerning expectations, roles, and guidelines. This information is sometimes obtained from other students through the grapevine(Gardner, 2007), but Lovitts (2001) questions the reliance on the graduate subculture in this manner, since some students are disadvantaged by distance, time, or some other impediment, and are inadvertently being set up for failure by not having sufficient access to important information.

The source of doctoral programmatic information is the academic department, which has been described as the chief orchestrator for the doctoral experience (Golde, 2005). Although graduate students are responsible for knowing policies and other departmental materials, departments may often assume that students understand formal requirements and informal expectations (Lovitts, 2001).

Some departments provide little information on university and faculty regulations, guidelines, and requirements for the structure of the thesis (Cloete et al., 2015; Gardner, 2007), while others delegate information about important matters to the student grapevine (Lovitts, 2001). If students are ill-informed or have little connection to peers and faculty, confusion about program expectations, miscommunication, and feelings of social isolation may be the result (Ali & Kohun, 2006; Lovitts, 2001). In many cases, students will rely on the supervisor to explain important departmental issues and to provide departmental requirements and milestones, if they are not apparent elsewhere (M. Jones, 2013).

During the process of creating the dissertation, informal interaction enables tacit information to be passed, and vicarious learning allows the values and practices of others to be observed. The total doctoral interactions provide a means for the doctoral student to create a cognitive map of the way ahead. In doctoral learning, the principal interaction form is with the supervisor, but the other forms also add value to varying degrees, such as interaction with the academic environment. Since the environment engenders programmatic information, the sense of isolation present in doctoral students may be magnified if students are confused about program requirements (Ali & Kohun, 2006; Brill, Balcanoff, Land, Gogarty, & Turner, 2014; Lovitts, 2001). This interaction also adds value if the supervisory relationship is missing or impacted or if peers are unavailable for support. Interaction with other students is minimized during the dissertation process, but it could be incorporated into doctoral learning with different pedagogical approaches. The next section will describe issues and constraints and the development of risk profiles for non-traditional doctoral students. After that, the theory on the EQuiv is discussed, leading to the proposed expansion of the theory for non-traditional doctoral students.

Interaction in Distance Education

Due to the advent of bidirectional communication technologies, the principal distance education research topic is interaction, which is of special worth to distance education (Wang et al., 2014). This technology also enabled the social constructivist pedagogy, in which knowledge is personally constructed and validated socially (Anderson & Dron, 2011). In Wanstreet's (2006) review of DE interaction related journal articles, he noted three conceptual frameworks of interaction: (a) interaction as an instructional exchange between the three modes of interaction, (b) interaction as a communication method, assisted by technology, and (c) interaction as a Vygotskian psychological and social exchange.

Interaction is viewed by Dewey (as cited in Anderson, 2003a) from a constructivist perspective as the receiving of information which is transformed into personally meaningful and applicable knowledge. This information may be transformed on a one-time basis, or longitudinally, over time. For purposes of learning, Anderson (2003a) distinguishes interaction by *educational context* and *value to the process of learning*, so informal interactions such as pub chatter or air traffic control dialog have little educational value (in his estimation), but he allows that informal interactions leading to learning are still possible outside of the formal educational setting. Moreover, since formal and informal learning can be an outcome of interaction with peers and content, the absence of a teacher does not define interaction in an educational context.

Interaction is also multifaceted. One facet is *depth*; Bernard et al. (2009) distinguish between *surface interaction* and *deep interaction* – in which surface interaction (an example of which is seeking the correct answer) is deemed to be efficient, with an outcome of superficial learning, while deep interaction (e.g., seeking an explanation) has an outcome of complex learning, as a result of effective communication. A second facet of interaction is *strength*, but it is seldom employed as such, except by those exploring the EQuiv such as Bernard et al. (2009), Rhode (2009), Anderson (2003a, 2003b) and Miyazoe and Anderson (2010a, 2010b), to name a few examples. Still another facet of interaction is *purpose,* or the intent of the interaction (i.e., subject). As an example, the theory of transactional distance explains that one purpose of interaction is to reduce the psychological distance between a

student and source of learning (Moore, 1997). Other mentioned purposes of interaction are transmitting information (Aghaee et al., 2016), generating learning (Bernard et al., 2009), reducing isolation (Ali & Kohun, 2006), enabling persistence (Bair & Haworth, 1999; Tinto, 1993) and contributing to socialization, especially in doctoral education (Lovitts, 2001).

Interaction is a defining characteristic of DE, along with its essential interactions of student to teacher, student to content and student to student (Moore, 1989, as cited in Miyazoe & Anderson, 2013). The traditional DE learning method (correspondence) shows a high level of S2C interaction, with low amounts of S2T and S2S interactions (Anderson, 2003a). Students in traditional classroom arrangements have a medium to low interaction level with content and a medium interaction level with the teacher. This pedagogy can be attributed to historic times, when scarcity of content (e.g., books.) created a need for students to absorb information from the lectures of teachers, who provided the knowledge to be learned (Anderson, 2003b). The next section will discuss EQuiv in more detail.

The Interaction Equivalency Theorem (EQuiv)

The EQuiv was derived from the inductive reasoning of Anderson (an experienced DE educator) after he noted that no single type of interaction is superior in support of the DE educational process. Students learn in a variety of ways, so that a given subject or lesson may be taught by a teacher, it may be learned from other students, or it may be obtained by content. Anderson also noted that DE students preferred a variety of educational delivery methods; with some students choosing situations that minimized or even eliminated interaction with other students and the teacher (Anderson, 2003a; Miyazoe & Anderson, 2010a).

The EQuiv was developed as a theory that explains interaction in DE, succeeding Moore's (1989) three-part model of interaction, which consists of the interaction dyads of the student to content (S2C), student to teacher (S2T), and student to student (S2S). The definition of student and teacher are self-explanatory, but content is more ambiguous, since Anderson (2003a) classifies as student to content (S2C) certain interactions between students that substitute for the student to teacher (S2T) interaction (e.g., asynchronous e-mails in discussion forums, and videos, interactive media and assessment programs. Anderson advanced Moore's three-part model of interaction into a theorem with two perspectives of quality and quantity (Miyazoe & Anderson, 2010a). In Thesis 1, the EQuiv recognizes that the three essential interactions are equal and interchangeable. Thesis 2 notes that although more interactions may be even better, they are subject to the boundaries of time and cost (Moore, 1989, as cited in Anderson, 2003a). Moreover, a mix of interactions is possible within the given cost and time constraints.

According to Thesis 1 of the EQuiv, only one strong form of the three interaction dyads (S2C, S2T, and S2S) is necessary for deep and meaningful formal learning, and these interaction dyads are equivalent to each other (Miyazoe & Anderson, 2015). To be considered strong, actors in an interaction needed to be "personally active and engaged in the interaction" (Anderson, 2003a). Thesis 1 pertains to the situation of closed systems, whereby time and resource constraints dictate the selection of one strong form of interaction over another. Thesis 2 applies to open systems, in which accidental interaction surpluses, such as a guest instructor are possible, and which add to learning. However, if another strong form of interaction is added, it will cost more, and add more time (Miyazoe & Anderson, 2011). Although the addition of more interaction types of the same strength may be beneficial, there are still cost and time considerations. (Figure 2) (Jones & Bogle, 2007, adapted by authors).

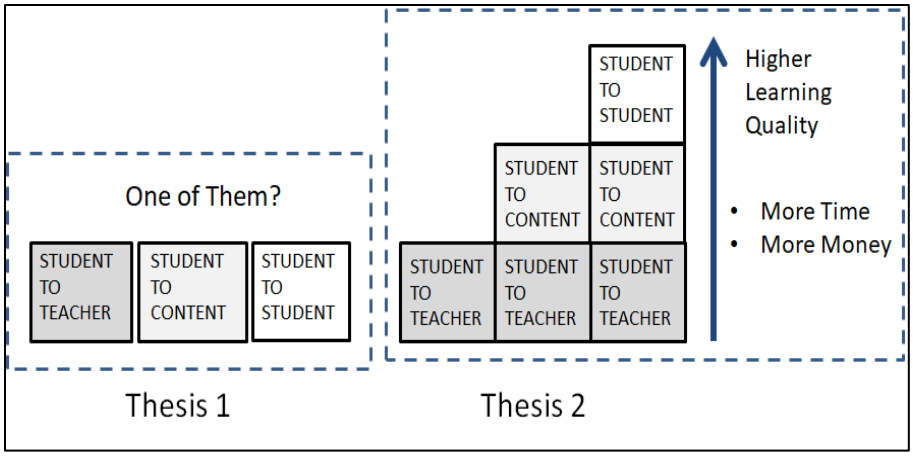

Figure 2. The Interaction Equivalency Theorem

Although Anderson (2003a) does not specifically define deep and meaningful learning, Garrison and Cleveland-Innes (2005) indicate that deep learning is but one of three key learning approaches (the others being surface learning and achievement), whereby the quality of interaction is more important than quantity. Deep and meaningful engagement is achieved when the discussion is followed, the discourse is reflected upon, and individual meaning is constructed. Deep learning is contrasted to surface learning, which is merely rote learning (Garrison & Cleveland-Innes, 2005). As previously stated, Bernard et al. (2009) view learning in terms of complexity and desired result. Effective communication is the product of deep interactions such as seeking an explanation. In contrast, efficient communication may be achieved from surface interactions such as seeking the correct answer.

The EQuiv from a DE course designer's perspective

The EQuiv was designed to be viewed from the perspective of a DE course designer, with the underlying assumptions that the course or program may have time and funding constraints, the outcome is learning, and the something to be learned is the same for all methods of learning. Course designers wishing to use the EQuiv as a framework will have several considerations, which will be described in this section. In the DE context, various factors must be considered in the design of a DE program to ensure sufficient interaction, namely the approach to learning, the mode of delivery (e.g., classroom), course designer preference, and the market value (Anderson, 2003a).

The *approach to learning* determines the level and types of interaction employed, with constructivist approaches to learning and collaborative tasks having a high level of S2S interaction in programs that are designed to be interactive among peers, or that permit this interaction, while other approaches (e.g., cognitive and behaviorist) have less of a requirement for S2S interaction (Anderson, 2003b; Wang et al., 2014). Regarding *value*, all forms of interaction although equivalent, are not of equal value to course designers, the market, and students. While the S2C interaction is much more valuable to a course designer due to its substitutability with S2T and S2S, the S2T interaction can be fully substituted with autonomous teacher agents and rich content, and partially substituted with e-mail. It is interesting to note the importance of the S2S interaction to collaborative tasks and constructivist approaches to learning (Anderson, 2003a).

Since interaction is expensive in any format, cost and time constraints apply to all concerned parties - students, teachers and organizations (Miyazoe & Anderson, 2013). As an example, in addition to more time, adding an S2T interaction in a S2C course might require more teachers, while adding more S2C might require additional textbooks or revision of departmental websites. Also, a high level of satisfaction warrants more time to be expended in the learning experience, which is a disadvantage to distance learners, who are often employed (Miyazoe & Anderson, 2013). Subsequent empirical research afforded students with the opportunity to prioritize these interaction types, so that if only

one strong type of interaction were offered, it would be the most preferred form for the particular situation (Miyazoe & Anderson, 2010b).

Mode of delivery is relevant to types and levels of interaction. It is important to note that for each delivery mode, more than one type of interaction may be employed. As an example, in a traditional classroom setting, a medium level of S2T interaction is likely to be present, along with low levels of S2S and a low to medium level of S2C. Videoconferencing in a dedicated learning facility has a medium level of S2T in addition to a high level of S2S if it is built into the course, along with beneficial, face to face informal 'side talk' while in the facility. However, traditional video conferencing does not share the side talk benefit (Anderson, 2003a). The choice of media for synchronicity will depend on factors such as preference, cost and convenience (Anderson, 2003b).

Market value and *course designer preference* for the three essential interaction types is also a consideration since they are not of equal value to course designers and the market. According to Anderson (2003a), the S2T interaction is the least flexible, is the most difficult to scale, it has the highest value to students and the market, and is the target of substitutability for DE. The S2T interaction can be fully substituted with teacher agents and rich content, and partially with e-mail, with administrative tasks associated with teaching being handled by content. On the other hand, course designers value the S2C interaction most due to its substitutability with S2T and S2S. It is interesting to note the importance of the S2S interaction to collaborative tasks and constructivist approaches to learning. Shale (1990, as cited in Anderson, 2003a) notes that the S2S interaction is the most social of the DE components since it allows DE to move from independent study to education at a distance. Subject orientation is also important, since skills-oriented courses (e.g., language) warrant more activities and simulations, while knowledge-oriented courses (e.g., history) allow for more traditional, less interactive designs (Miyazoe & Anderson, 2010b). It is also imperative to note that context is important in the use of the EQuiv, which few researchers have discovered. The literature concerning the EQuiv is addressed in the following section.

Current empirical research on the EQuiv

Some researchers have recognized the subjectivity (and relativity) of the EQuiv. In his dissertation, Cabral (2015) muses:

> [O]ne of the difficulties that arose right from the beginning, (and although they have been discussed directly with Terry Anderson and Terumi Miyazoe) relate to a failure to qualify what is meant by high interaction, moderate or low. Even if you define some indicators, it is quite difficult to understand, from context to context, what each one means. To a short course aimed at professionals in a given area, the interaction can be considered high for the student-content; perhaps in another context in which the same contents were applied, but this time for an undergraduate course for full-time students, the student-content interaction could be probably be considered moderate or even reduced. Thus, this perception will always have a subjective component. (p. 225)

In addition to its subjectivity, although the EQuiv appears to be a straightforward and simple set of relationships, it is highly nuanced regarding delivery mode, academic approach, and synchronicity, which is not always understood by researchers.

Moore's three modes of interaction (1989) is the first systematic research and the main theoretical construct for interaction research (Wang et al., 2014), and virtually all EQuiv research is based on this construct. Interest in the EQuiv is ongoing and global, with approximately 25 studies from 2007 through 2018. The majority of EQuiv empirical research concerns interaction preferences and equivalency/substitutability, or intensity of interactions and learning outcomes, which will be discussed in this section. Although 17 corollaries and implications in the EQuiv must be heeded (Anderson, 2003a), it is clear that researchers fail to comprehend or adhere to these caveats, so many research

designs are inadequate. One example is a corollary that the S2S interaction is considered to be vital for designs based on constructivist learning approaches, but it is not as important to designs based on cognitive and behaviorist learning approaches (Anderson, 2003a). Few EQuiv studies recognize this distinction, so the error is built into the research design.

Interaction Preferences and Substitutability. The study of interaction preferences is related to Thesis 1, which states that all three interactions are equivalent. Numerous EQuiv studies indicate that formal interaction with students is the least preferred option (Apostolopoulos, 2014; Cabral, 2015; Rhode, 2009). However, in some cases, Thesis 1 is deemed to be only partially supported, but this is due to the differential treatment of the S2S interaction within the research. Reasons given by researchers is that S2S is not practical within the course (Rhode, 2009), it was not integrated into the course (Holmes & Prieto-Rodriguez, 2018; Yu, 2013), it was not required in the course, or it was not perceived by the researcher to be present (Apostolopoulos, 2014; Nieuwoudt, 2018). One study asserts that all three interactions are equivalent, but the three concurrent identical courses in a multimodal blended learning environment were based on independent learning and were not collaborative, so a finding that S2S is least preferred is not conclusive (Yu, 2013). It is interesting to note that although formal S2S interaction is least valued in many studies regardless of synchronicity, informal peer interaction is greatly valued by students (Holmes & Prieto-Rodriguez, 2018; Rhode, 2009). Also, Anderson (2003a) also notes the value of side talks at video-teleconferences held at dedicated locations.

In one study, formal S2S interaction within the Learning Management System (LMS) of a self-paced course was least valued, but informal peer interaction from blogs and social bookmarking added to the quality of the course (Rhode, 2009). Facebook participation was a determinant of persistence in one Jamaican study (R. A. Jones & Bogle, 2017), whereby students in blended undergraduate courses conducted on the Facebook platform were separated into control and experimental groups based on participation in instructor-led Facebook activities. Those who did not participate in the activities were placed in the control group, while those who participated became the experimental group. The majority of students in the control group had a less than 2.70 Grade Point Average (GPA), while the GPA of the experimental group was 3.7. Credit for greater success was given to the Facebook interaction group due to an enhanced S2T interaction, but other interactions such as S2S real-time chats, a learning assessment, and the online assessment were also of significance.

The formal S2T interaction is preferred by face to face students and students in blended courses (Apostolopoulos, 2014; Miyazoe & Anderson, 2010b) or a combination of S2T and S2C (Rhode, 2009, Yu, 2013). In a Greek study of a blended learning skills-based course for working-age adults (Apostolopoulos, 2014), students were required to learn Moodle, in addition to another language and the course itself. When queried, these students preferred S2T followed by S2C. Although the students were a homogenous group of educators and had similar study times, they reportedly did not collaborate or interact with each other synchronously despite having contact with each other during a trip to the campus for lectures, presentations and workshops. However, the study did not assess nor consider the possible informal collaboration outside of Moodle such as in-person side discussions during the trips or personal e-mails.

In other studies where preferences are sought, a preference for the S2C interaction is expressed for independent DE courses, corporate courses, and online programs (Miyazoe & Anderson, 2010b; Rhode, 2009; Rodriguez & Armellini, 2013). In a survey of self-paced online graduate students, Rhode (2009) questions the concept of equivalency, since students only recognize the equivalency of S2C and S2T interactions. However, Rhode (2009) notes the course design limits the S2S interactions, due to impracticability. In addition to course design affecting the outcome, the research design is also a factor. In a study by Rodriguez and Armellini (2013), worker perception of various interaction types and effectivity in a Mexican online employee training courses was evaluated, but the course only had an S2C interaction. Although the employees preferred the S2C interaction, no other interaction was designed into the training. Moreover, when questioned, employees did not consider all inter-

actions to be of equal value. Regarding effectivity, employees considered the training to be effective (Rodriguez & Armellini, 2013). A subsequent research effort use all three interactions in three separate courses, but the instructors in one S2T focused course failed to teach, and in another S2S focused course, students were passive (Rodriguez & Armellini, 2014).

Regarding substitutability, the S2T interaction is a candidate for substitution (Anderson, 2003a). The literature revealed two examples, one being a partial substitution of S2S for S2T, and one inferring an S2C substitution. In the first case, Markewitz (2007) sought to validate the substitutability of the S2T interaction with S2S in two simultaneous versions of an online course. Group A had the capability for S2S interaction, while Group B did not. Each group had identical course content, student population, and level of instructor interaction. Group A had higher test scores and fewer S2T interactions than Group B. However, much of the S2T interaction in Group B was related to course administrative issues (which relates to explicit knowledge), not to content (Markewitz, 2007). In the second example, Byers (2010) surveyed 85 educators who had completed a self-paced, interactive web course. In conjunction with pre and post assessment instruments, the survey indicated a preference for the most interactive S2C strategies, with the least preferred strategies having little interaction. Based on these results, Byers (2010) concluded that a strong S2C interaction can compensate for interactions with teachers and other students.

In one review of the online education literature, the role of the S2T and S2S interactions is compared to satisfaction and persistence. Findings were that student participation in class and faculty interaction correlate with persistence (Croxton, 2014). However, students were most satisfied with courses having a higher level of S2C interaction, but satisfaction pertained to one-on-one interactions (especially S2T), while team interactions were not particularly valued. However, peer feedback is valued more at the doctoral level and in undergraduate level courses. For S2T interaction, although this interaction was paramount to student requirements, the interaction quality or quantity was not addressed, save for the value of timely feedback. Regarding S2S, it is negatively correlated to satisfaction in some circumstances (Croxton, 2014).

Strength of Interactions. Some studies address interaction strength in various forms. In a meta-analysis of the DE literature from January 1985 to December 2006, Bernard et al. (2009) used the construct of Interaction Treatments (ITs) to review various forms of DE, to discover the relationship between interaction strength and achievement, and to determine the effectiveness of various interaction combinations. The meta-analysis found that increasing an IT leads to positive outcomes, and some combinations (S2S and S2C, and S2T with S2C, but not S2S and S2T) contributed to higher achievement outcomes (Bernard et al., 2009). In a longitudinal study of an online graduate-level LMS (Joksimović, Gašević, Loughin, Kovanović, & Hatala, 2015), results revealed that foundational courses (i.e., prerequisites) had a strong S2C interaction, but a strong S2T interaction had a positive outcome. In core courses (discipline related), more S2S interaction occurred than in the foundational courses, but a strong S2T interaction had a negative effect on the outcome. In elective courses (specialization), more S2S interaction occurred, with a positive outcome for a strong S2T interaction. Joksimović et al. (2015) found a Student to System (S2SYS) interaction is associated with greater satisfaction and learning overall, while the S2C interaction is the most negatively associated; the researchers speculating that perhaps weaker students needed to return more often to the course material, whereas a strong interaction with the (S2SYS) showed the greatest proficiency. This finding is contrary to the research of Bernard et al. (2009), Rhode (2009) and others, who had a positive correlation with a strong S2C interaction.

In another study of an LMS (Nieuwoudt, 2018), interaction and participation were compared to course outcomes in two sessions of an online course. For the S2T interaction, each session had live synchronous instructor sessions and a live chat with the instructor (these were recorded for students who were not able to attend). For S2C, content folders containing presentations and other course material were available. In the case of S2S, although discussion forums were available, participation was not mandatory, nor was it graded. A pdf study guide was available in the first session, while the

second session had the pdf study guide plus an interactive version of the study guide. The second session outperformed the first session in a comparison of grades, the quantity of emails to the teacher, online interaction and online participation. While students in both sessions sent e-mails to the instructors and attended the live sessions in comparable amounts, more time was spent on the interactive study guide in the second session. Although most of the interactions were S2T questions in the discussion forums, a positive correlation was found between grades and the number of e-mails to the teachers. Although there was a significant relationship between success and online learner participation in the LMS, it was not true for online interaction, which was deemed more difficult to discern.

The relationship of achievement to interaction intensity was measured in a study of three Catalan universities (Castaño-Muñoz, Sancho-Vinuesa, & Duart, 2013), one of which had an online individual study program. Students in classes conducted online and face-to-face were surveyed as to participation in four categories: (a) communication with lecturers, (b) communication with fellow students, (c) cooperative work with fellow students, and (d) participation in online discussions on a particular subject. The interaction intensity was determined by the number of categories reported. While the use of three categories was reported as being nearly equal (28. 93% for online and 26. 35% for face to face), use of all four categories was reported by 41% of the online students, but only 11% of face to face students. The study concluded that Thesis 2 was supported by this research since online students took a smaller number of classes and had a higher achievement rate, which showed diminishing returns for increasing the number of uses. However, although the researchers do not aggregate the data other than by some categories, a possible reason for a precipitous drop-off of face to face students from three to four categories is that the face to face classes may not have had online peer discussions in the course structure.

Other Criteria. Two studies employ the EQuiv as a framework; the focus of Ying (2011) is the relationship of type of assistance requested to deep and meaningful learning. As a student tutor in an online Taiwanese calculus tutoring program, Ying saw a variety of requests for assistance, classifying student's questions into surface and deep learning categories using a problem-solving discussion coding scheme. Ying was able to determine which students did not experience deep and meaningful learning in the past and at what grade levels. He observed that 87% of the requests were assigned the P1 level ('problem proposal or definition clarification'), with most discussions being coded as sub code 2, (not associating key concepts to the overall calculus problem). From this, Ying inferred that sub code two students had minimal S2T and S2C interaction while in college, while the next largest group (Sub code 1: unfamiliarity with basic knowledge) indicates a low S2T and S2C interaction in the grades before college. Through deductive reasoning, Ying concluded that students making a P1 request had low levels of all interaction types (and therefore did not experience prior deep and meaningful learning), since in the EQuiv, at least one strong interaction was needed for deep and meaningful learning. The second study (Thupayagale-Tshweneagae & Sibanda, 2015) is a preliminary effort that correlates interaction frequency, persistence, and the EQuiv at the doctoral level. They cited the frequent SMS text interactions and phone calls between student and supervisor (under severely degraded communication conditions) as the reason for the persistence of the student. It also provided a vehicle obtain the knowledge needed to complete the dissertation. However, the relationship to the EQuiv is not explained nor justified.

Except for Miyazoe and Anderson (2010b), Ke (2013), and Cabral (2015), few studies encompass all three interaction modes or test both theses. In Miyazoe and Anderson (2010b), different learning modes and all three interactions are used to validate the EQuiv. Students from 11 different classes and learning modes in four Asian universities ranked Moore's three modes of interaction (Moore,1989, as cited in Miyazoe & Anderson, 2010b). Students in face-to-face (F2F) or language-oriented courses valued student-teacher (S2T) interactions most, and interactions with content (S2C) least. However, students in online or knowledge-oriented courses placed a higher value on student-content (S2C) interactions and least on student to teacher (S2T) interactions (Miyazoe & Anderson, 2010b). In the blended course designs, when students were in the F2F learning environment, they

responded accordingly, but as they were increasingly exposed to online asynchronous interaction with other students, a perceptual change in preference and importance of interaction elements over time (Miyazoe & Anderson, 2010a). Thesis 1 is confirmed because students have distinct criteria for preferences, and Thesis 2 is partially confirmed because students can rank these preferences (Miyazoe & Anderson, 2010a). The fact that interaction preferences exist in different sequences supports their overall equivalence.

Cabral (2015) explored three versions of an online course at an online Portuguese open university with identical program structure, but with varying contexts. Version 1 of the course had high S2C and minimal S2S and S2T interactions, Version 2 had high S2T and minimal S2C and S2S interactions; while Version 3 had both high S2C and S2T interactions, and reduced S2S (This last version was the most preferred in a survey that was part of the study and led to the formation of the test classes). Each version of the class contained three modules with the featured interaction in each module, with the fourth module having a heavy S2S component. Although the first two objectives of the study did not confirm or disprove the first and second EQuiv theses, preliminary survey responses led to the scenario that is preferred by students (Class 3), but the design produced no significant differences in satisfaction. However, the data confirmed Bernard et al. (2009) as to increased costs of additional interactions. For the third objective, the lesson learned is that the S2C interaction should be first employed, with teachers facilitating as required and other students discussing and debating ideas. The last objective was satisfied as a result of the student-teacher interactions, which led to improvement of the applied questionnaire, which in turn provides clarity of the meaning established interactions. The most significant finding is that, regardless of preference, students appreciated the S2S interaction in the fourth module, indicating that they learned even more in this module than the others (Cabral, 2015). However, since the fourth module was designed for S2S interaction, equivalency was not addressed for that particular module, only that the students saw value in the interaction in the correct setting.

Table 2 is a matrix of the EQuiv literature by category, subcategory, attribute and citations, it is not all inclusive, but is representative of the literature. The design was adapted from the Researcher Development Framework as employed by Yazdani and Shokooh (2018).

Table 2. Categorized Matric of EQuiv Studies

Category	Subcategory	Attribute	Citations
Research Design	Number of Interactions in Design	Single Interaction	Byers, 2010; Rodriguez & Armellini, 2013; Thupayagale-Tshweneagae & Sibanda, 2015.
		Two Interactions	Castaño-Muñoz, Sancho-Vinuesa, & Duart, 2013; Croxton, 2014; Markewitz, 2007
		Three Interactions	Bernard, et al., 2009; Cabral, 2015; Ke, 2013; Kuo, Walker, Belland, Schroder, & Kuo. 2014; Miyazoe &Anderson, 2010b; Rodriguez & Armellini, 2015.
	Social Constructivism Considered for S2C	In Research Design	Cabral, 2015
Learning Method	Face to Face	Castaño-Muñoz, Sancho-Vinuesa, & Duart, 2013; Miyazoe &Anderson, 2010b.	
	Blended	Apostopolous, 2014; Cabral, 2015; Kuo et al., 2014; Miyazoe &Anderson, 2010b; Yu, 2013.	
	LMS	Apostopolous, 2014; Cabral, 2015; Ke, 2013; Kuo et. al., 2014; Rhode, 2009	
	Other Online	Byers, 2010; Castaño-Muñoz, Sancho-Vinuesa, & Duart, 2013; Miyazoe &Anderson, 2010b; Rodriguez & Armellini, 2013.	
	Social Media	Jones & Bogle, 2017	

Category	Subcategory	Attribute	Citations
Course/Program	Course Type	Single Course	Kuo et al., 2014
		Self-Paced Course	Byers, 2010; Rhode, 2009.
		Professional Development	Byers, 2010
		Organizational	Rodriguez & Armellini, 2013
	Program	Masters	Ke, 2013; Kuo et al., 2014
		Doctoral	Cabral, 2015; Thupayagale-Tshweneagae & Sibanda, 2015
Learning Approach of Course or Program	Knowledge	Skills-Based	Apostopolous, 2014
		Knowledge Oriented	* other than skills base, not listed
Students	Traditional Students	Undergraduate	Miyazoe &Anderson, 2010b
		Graduate	-
		Doctoral	-
	Adult Students	Undergraduate	Ke, 2013; Rhode, 2009.
		Graduate	Apostopolous, 2014; Kuo et al., 2014.
		Doctoral	Cabral, 2015; Thupayagale-Tshweneagae & Sibanda, 2015
		Academic Professional Development	Byers, 2010
		Corporate Learners	Rodriguez & Armellini, 2013
Interactions	Preferences	Apostopolous, 2014; Cabral, 2015; Croxton, 2014; Jones & Bogle, 2017; Holmes & Prieto-Rodriguez, 2018; Markewitz, 2007; Miyazoe &Anderson, 2010b; Nieuwoudt, 2018; Rhode, 2009; Rodriguez & Armellini, 2013; Yu, 2013.	
		S2C Most Preferred	Byers, 2010; Rodriguez & Armellini, 2013.
		S2T Most Preferred	Apostopolous, 2014.
		S2S Most Preferred	Ke, 2013
	Formality	Formal	-
		Informal	Rhode, 2009
Time and Cost	Salamati, 2012		
Social Media Used	Facebook	Jones & Bogle, 2017	
Substitutability	Full	-	
	Partial	S2S for S2T	Markewitz, 2007
Interaction Strength tied to outcome	Bernard et al., 2009; Byers, 2010; Castano-Munoz et al. 2013; Joksimović et al., 2015; Thupayagale-Tshweneagae & Sibanda, 2015; Ying, 2011		
EQuiv as Utility	Predict student background	Ying, 2011	
	Retention tool	Thupayagale-Tshweneagae & Sibanda, 2015	
Conclusions	Supportability	EQuiv is mostly supported	Cabral, 2015; Byers, 2010; Ke, 2013; Kuo et al., 2014; Rodriguez & Armellini, 2015; Thupayagale-Tshweneagae & Sibanda, 2015
		EQuiv is partially supported	Rhode, 2009
		EQuiv is not supported	-
	Substitutability	S2T may be substituted for with another form of Interaction	Markewitz, 2007 (partial S2S for S2T);
	Equivalency	S2S is not equal in some situations	Rhode, 2009

In summation, the literature on the EQuiv is contextual, relative, and inconclusive. While the S2T interaction is preferred in face to face situations (Miyazoe & Anderson, 2010b), the S2C and S2T interactions are preferred in DE in varying orders (and sometimes together), depending on the design of the study and course (Cabral, 2015; Jones & Bogle, 2017; Rhode, 2009). Although the EQuiv literature is nearly unanimous on the least preferred status of the S2S interaction (Byers, 2010; Rhode, 2009; Salamati, 2012), study design issues are responsible for some of the negative outcomes, since the S2S interaction is best suited for skills based courses or with a socially oriented learning approach (Anderson, 2003a). Regarding substitutability, one study (Markewitz, 2007) concluded that S2S could substitute for S2T when non-subject matter was needed, while another indicated that one interaction could suffice for the other two if sufficiently strong (Byers, 2010). Although Bernard et al. (2009) indicate that designing interaction into a DE course is beneficial for all forms of interaction, only strengthening the S2C interaction improved outcome, and only interaction combinations with S2C are positively implicated.

Moreover, the relationship of interaction strength and achievement applies only to asynchronous DE courses. The second example of interaction strength pertained to numbers of interaction types selected but did not consider all aspects of the study design, since one option may not have applied to all students (Castaño-Muñoz et al., 2013). Deficiencies in the EQuiv literature continue. Although one of the main tenants in the EQuiv is the optimization of interaction in order to reflect cost and time constraints, this aspect had not been sufficiently addressed (Miyazoe & Anderson, 2011, 2012) However Cabral (2015) adds a second strong interaction in the second class of his study with the intent of proving additional time.

In addition, although the value of learning in informal interaction outside of the classroom is recognized (Anderson, 2003a), it is not accommodated in the EQuiv literature. Additionally, scarce evidence exists of the EQuiv as a framework, with the exception of two studies. One uses reverse EQuiv logic as a method of determining the academic background of students (Ying, 2011), and the other employs the EQuiv as a framework to support a non-traditional distance doctoral student through the use of a single strong S2T interaction throughout the program (Thupayagale-Tshweneagae & Sibanda, 2015). However, the latter study is preliminary and not supported with sufficient justification. Therefore, a large gap remains in the EQuiv and doctoral student experience literature, since in addition to the paucity of information about doctoral level interaction in the EQuiv, little has been written about the support to non-traditional students under the U.K. form of doctoral learning.

Academic programs are designed for the traditional student who is young, male, full-time, and poised to succeed. However, the nontraditional student is often marginalized, since academic programs are not designed to consider factors that may affect persistence (McAlpine et al., 2012; Naidoo, 2015). As an example, although interaction is important component of all forms of education, and is essential to academic integration, nontraditional students (who may be older, part-time, off-campus, from another culture, handicapped, or economically disadvantaged, etc.) are more likely to experience insufficient interaction as compared to traditional students (Bean & Metzner, 1985; Moore, 1989; Offerman, 2011). This category of students may also experience attrition rates that are higher than traditional counterparts, according to anecdotal evidence (Bean & Metzner, 1985; Cotton et al., 2017).

Doctoral students may be negatively affected by three types of interaction insufficiencies, which are listed as follows: (a) insufficient supervision, (b) insufficient peer communication, and (c) insufficient information about the doctoral program (Aghaee et al., 2016). In the master-apprentice form of doctoral education, only one principal form of interaction (student-teacher) is present, so the supervisor becomes the primary agent of socialization. If this interaction is impaired, it can lead to the student not being integrated academically and not having the necessary knowledge to produce a dissertation, which can lead to feelings of isolation and dropout (Ali & Kohun, 2006; Lovitts, 2001; Wisker & Robinson, 2013). In the case of nontraditional students under the master-apprentice system, they

may be at still a greater risk due to reduced opportunities for interaction. Even though the number of nontraditional students is increasing, this problem is not visible, since most doctoral studies literature is of U.S. origin (M. Jones, 2013), the attrition and retention models do not reflect the nontraditional doctoral student (especially in a master-apprentice arrangement), and the retention statistics are not designed to capture them.

To improve doctoral retention, development of risk profiles and establishing interventions to help with integration are recommended (Aljohani, 2016b; Cloete et al., 2015). Since doctoral education is a form of DE, one possible intervention would be the EQuiv, which has its origin in DE. One of the main objectives of DE is to replace the S2T interaction with one that is more efficient and economical. The EQuiv is to be viewed from the perspective of the course designer, who must consider approach to learning, mode of delivery, and market value, in addition to personal preferences. In the EQuiv framework, one strong interaction is equivalent to another of the same strength and may be substituted for the other. Additional forms of interaction may be added, but they will cost more and take more time. One alternative option is to reduce the strength of the first interaction and add a second or even third interaction form of weaker strength (Aghaee et al, 2015; Anderson, 2003a). The questions raised by the literature as to the equivalency of the interactions (e.g., S2S) are best answered in the corollaries and caveats of the EQuiv.

RECOMMENDATIONS

This article seeks to find solutions for nontraditional doctoral students who are at risk of dropping out due to insufficient interaction and, thus, incomplete socialization. However, suggestions for risk identification lie outside of the scope of this article. This article restricts itself to suggesting a remediation for an impaired S2T interaction through the lens of the EQuiv, once the student has been identified. Although the EQuiv literature does not present clear solutions or themes, it is due to a lack of understanding of a theorem that is more complex than most researchers have understood. Since doctoral learning is transmitted by socialization at the dissertation stage by the supervisor in the master-apprentice form of doctoral education, it is likely that social solutions are warranted. The EQuiv offers a perspective that allows for the optimization of reduced interaction by adding another form of interaction up to the constraint of time or resources.

Regarding the review of the empirical literature on EQuiv, it consists of seeking the opinion of students as to their interaction preferences or attempting to prove its validity in some way. Few have explored the cost/time aspect, but it is heartening to see that several envisioned the EQuiv as a learning perspective. In the course of responding to the research question of the utility of the EQuiv in the process of interaction optimization of non-traditional students under the master-apprentice form of doctoral education, the following other findings were made.

Most EQuiv research does not pay attention to the cautions of Anderson (2003a), so the literature is based on situations that do not reflect the intent of the EQuiv. Additionally, the socialization requirements of traditional doctoral students under the master-apprentice system are unclear, and so the requirements of nontraditional doctoral students under this system are also not specified. Although institutions are urged to develop risk profiles based on characteristics of students who have dropped out, examples of these profiles do not capture the nontraditional doctoral student population. The literature does not capture the invisible problems of the nontraditional doctoral student who is under the master-apprentice form of doctoral education.

However, although it is outside the scope of this article to pursue the question of nontraditional doctoral student integration, it is still possible to envision a use for the EQuiv in the substitution or augmenting of the S2T interaction. Since doctoral education under the U.K. method is based on unique craft arrangements, individually tailored solutions are envisioned.

In Europe, doctoral education reform initiatives such as the 1999 Bologna Declaration and the 2000 Lisbon Strategy recommend changes in policy (Louw & Muller, 2014). Policy solutions that seek to

help with retention must be directed towards the institution and its representatives. In addition to the student; these must originate from the everyday interaction among students, faculty, and staff in the formal and informal domains of institutional life (Tinto, 1987, 1993, as cited in Bair & Haworth 1999).

Institution-based solutions include aligning the academic environment to support student needs, identifying traits associated with success and developing risk profiles of students likely to drop out, and performing cost-benefit analyses to help with retention decisions (Nichols, 2010).

Academic departments have been urged by the literature to develop risk profiles of students likely to drop out based on past historic attrition reasons within the department (Bair & Haworth, 1999; Nichols, 2010). Also, departments are urged to develop local questionnaires to survey the prevailing research climate, although surveys such as the Australian Postgraduate Research Experience Questionnaire (PREQ) and the U.K. Postgraduate Research Experience Survey (PRES) are widely used (Johnston, Sampson, & Brogt, 2016). Both incoming and ongoing students should be identified by risk profile to determine if interventions are warranted. This demographic information should be maintained and refined over time (Bair & Haworth, 1999).

Once the at-risk student has been identified, how does the EQuiv relate to the instance of non-traditional doctoral students working on a dissertation? Before this question is answered, several points apply. First, a generalization must be made that time and resources are likely considerations for this population since they are older, off-campus, part-time, self-financed, employed, and possibly with family responsibilities (Offerman, 2011). Second, recognition must be given that the interaction with the supervisor (S2T) is considered to be the most important interaction in doctoral learning at the dissertation stage (Lovitts, 2001), especially for time-constrained or distance students, and that substitution of this interaction with other interactions would be a goal of the EQuiv framework. Third, it must be recognized that other inhibitions (e.g., cultural, socio-economic) may apply to non-traditional doctoral students (Naidoo, 2015). Last, this framework applies to non-traditional doctoral students under the master-apprentice form of doctoral learning, but it may have some relevance to non-traditional doctoral students in the dissertation phase of U.S. style programs.

The doctoral literature reiterates the paucity of time for many non-traditional students (Gardner & Gopaul, 2012; Offerman, 2011) in addition to experiencing cultural disconnects for some (Weidman & Stein, 2003). Figure 3 depicts an intervention of a non-traditional doctoral student who has been identified as a potential risk by the department. Mary has only a certain amount of time to devote to studies, but her relationship with her supervisor is impaired due to cultural matters, so the interaction is less strong than it should be. To compensate for this issue, since the supervisor has a full workload, and no other supervisors are available, if she has a need for tacit information, Mary could be directed to online peer social groups or peer tutors, if necessary, in accordance with the benefit of informal peer interactions during the dissertation process (Nerad, 2012; Spaulding & Rockinson-Szapkiw, 2012). Under the EQuiv, since Mary's time for studies is unchanged in this example, and the peer social group is free of charge, then no additional time or resources are expended. Also, if she needs explicit information, additional written guidelines, online workshops, and writing assistance opportunities could be provided, which may or not be an additional expense. However, as previously stated, all interventions should be subject to a cost-benefit analysis (Nichols, 2010).

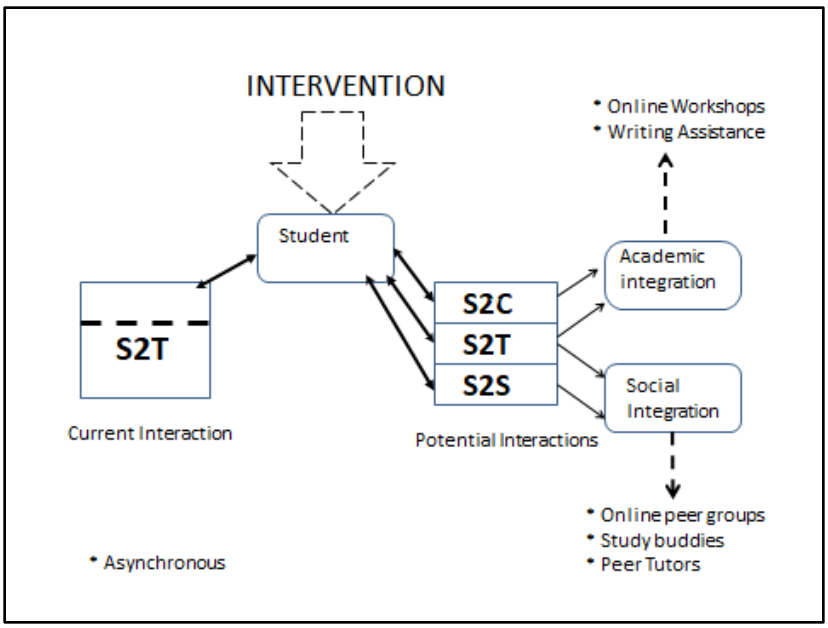

Figure 3. EQuiv Intervention Model for a Non-traditional Doctoral Student

Through the development of a process to identify at-risk students and assess their constraints, once the risks are mitigated through the optimization of interaction opportunities, the likelihood of feeling isolated will be reduced, which in turn will reduce the likelihood of attrition (Ali & Kohun, 2006). In addition to reducing feelings of isolation, the improved interaction opportunities may lead to greater academic and social integration, and an improved cognitive map.

In conclusion, if the student's constraints are related to time or resources, then the EQuiv may be a framework with which to offer support within departmental constraints (Anderson, 2003a). The EQuiv is not meant to be a mechanistic application of resources, but a way to offer individualized interaction support that is effective and efficient. Moreover, learning environments that adapt to supporting individual learning ways are likely to benefit in the form of reduced attrition. At best, by designing practices in congruence with doctoral students' ways of learning, scholarly communities can provide environments in which various doctoral students can flourish (Vekkaila & Pyhältö, 2016).

CONCLUSION

The non-traditional doctoral experience illustrates the shortcomings in the traditional view of support on this level. The EQuiv was originally developed for interaction support in a DE environment. Therefore the EQuiv literature has shortcomings regarding interaction support to non-traditional doctoral students. This article proposes that the EQuiv can be adapted to address challenges experienced in supporting non-traditional doctoral students. This article is of theoretical significance since it provides new conceptual understandings or insights into a familiar problem (Jansen, 2011). This study adds to the body of knowledge on the Interaction Equivalency Theorem in the following ways: Several conceptual proposals are offered, namely that more than one interaction is needed for doctoral learning, but given the constraints of time and money, these interactions will not be as strong. Furthermore, it posits that in the EQuiv, complex subjects, those requiring tacit knowledge, or programs require more than one interaction.

Further research on the Interaction Equivalency Theorem is proposed. The EQuiv in its current form has been largely confined to the distance education discipline, mostly focusing on structured courses. The article enlarges the scope of the theory to contribute to the field of doctoral education.

Further research could focus on further exploring the applicability of interaction preferences, substitutability and the strength of the interactions with this cohort of students. An adaptation of the EQuiv might assist practitioners in developing a risk identification process to support non-traditional doctoral students at risk within cost and time constraints.

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