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ABSTRACT

The ever increasing enrollment numbers and the corresponding dwindling educational resources in public schools have challenged the Ministry of Education in Malawi to introduce an instructional innovation (TALULAR) based on the use of locally available resources for teaching and learning. The purpose of this study was to determine: (i) whether, and to what extent, the perceived characteristics of innovations and teachers’ demographic and employment variables are useful in predicting the implementation of TALULAR, and (ii) the extent to which TALULAR has been implemented by secondary school science teachers in Malawi. Rogers’ (2003) diffusion of innovations theory provided the theoretical framework for the study. Using stratified random sampling, 269 science teachers, representing a response rate of 77%, provided data for this study. Among other findings, multiple regression analysis revealed that collectively, the perceived innovation characteristics are significant predictors of TALULAR implementation. The results further revealed that perceived relative advantage and perceived observability in terms of others’ use are the two most important predictors of TALULAR implementation, and that implementation of the innovation by science teachers is at a moderate level. These findings might contribute to a deeper understanding of science teachers’ perceptions of using the innovation and may aid change agents and agencies in planning a successful nation-wide diffusion campaign to ensure that all teachers not only adopt, but more importantly, implement the innovation in the classroom.
Dedication

This dissertation is dedicated to the following people: (i) my mother, Mrs. Dorice Gwayi, who worked tirelessly to bring me up in a very unfavorable environment infested by poverty, disease, hunger and nepotism, (ii) my brother, Mr. Ronald Gwayi, who is an extraordinary human being who dropped out of primary school to look for a job in order to finance my secondary school education, (iii) my late father, Mr. Mackson Gwayi, who was my role-model for hard work and persistence and who instilled in me the inspiration to set high goals and the confidence to attain them, (iii) my lovely wife, Elizabeth Gwayi, who has been supportive of my work and who shared the many challenges and sacrifices for completing this mammoth task, and (iv) my son, Wongani Elijah Gwayi, and my daughter, Thandiwe Sithembile Gwayi, who have now grown into wonderful six and two-year olds, respectively, in spite of their father being less available for them than he should have been during the critical years of their life.
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Chapter 1: Introduction and Need for the Study

Like most countries in the Sub-Saharan Africa, Malawi’s educational system faces a number of challenges, which have negatively impacted the quality of education. Such challenges include the following: (a) inadequate well-trained and qualified teaching force, (b) shortage of teaching and learning resources, (c) high repetition and drop out rates, and (d) large class sizes. Besides the shortage of well-trained and qualified teachers, one of the major educational challenges facing Malawi today is the critical shortage of basic teaching and learning resources in public schools at both primary and secondary school levels (Chilora, et al., 2003; Kadzamira & Rose, 2003; Lungu, 2005; Nsapato, 2005). The shortage of teaching and learning materials in Malawi’s public schools is attributed to government’s low educational financing due to poor economic growth, rapid population growth and demand for schooling. Fuller (1987) found that there was a strong relationship between the availability of teaching and learning materials and student achievement. The shortage of teaching and learning materials is one of the major factors that have contributed significantly to the deterioration of educational quality in Malawi as evidenced by students’ poor performance in national examinations, high failure rates (Davison & Kanyuka, 1992; Ndaferankhande, 2007, Yadidi, 2006), and high repetition and attrition rates (Maluwa-Banda, 2004).

In an effort to solve the problem of shortage and lack of teaching and learning resources, the Ministry of Education in Malawi through the Malawi Institute of Education (MIE) is on a nation-wide campaign encouraging teachers to adopt and implement an instructional innovation. This innovation is based on the utilization of locally available resources in the near environment for teaching and learning and is referred to as Teaching and Learning Using Locally Available Resources, TALULAR (Chilora, et al., 2003; Malawi Institute of Education [MIE], 2004).
According to Chilora et al., the term *Locally Available Resources* refers to what is readily available in the environment that could be used to promote effective teaching and learning in the classroom. TALULAR resources are not only limited to material resources but also include human, animal, and non-material resources. This innovation is based on the observation that resources available dictate the nature and quality of teaching and learning, and it seeks to address the problem of reliance on unsustainable, inaccessible and commercialized technological resources (Wankat & Oreovicz, 2001). While the shortage of teaching and learning resources has negatively impacted the quality of teaching and learning in all subjects, such effects are insurmountable for secondary school science subjects such as Physical Science (Physics & Chemistry) and Biology, owing to the nature and origin of their curricula. Although a number of curricula reforms have been undertaken since independence, science education in Malawi, as is the case with most former colonial states, has suffered a great deal because its curricula still mimic those of her colonial master (Gray, 1999; Wandiga, 1994). These curricula often prescribe expensive commercially produced resources (Wandiga, 1994), which are inadequate or do not exist in secondary schools today as the government can neither afford nor maintain them.

The TALULAR innovation is viewed as a major break through in solving the problem of shortage of teaching and learning resources and contributing to the improvement of educational quality in general and science education in particular. It is perceived to have a great potential in making science teaching and learning more interesting, more participatory, and more relevant and meaningful. Although TALULAR is apparently an important innovation as an alternative to the scarce and expensive commercialized teaching and learning resources, there appears to be a paucity of diffusion studies about this innovation. Therefore, no information is available to
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decision-makers in Malawi that could guide the diffusion process and make adoption and
implementation successful.

Statement of the problem

TALULAR innovation is meant to complement the commercially produced
instructional resources that schools are assumed to have. While it is the responsibility of the
government of Malawi through the ministry of education to adequately finance education and
provide resources that would enhance the quality of teaching and learning in schools, poor
economic growth, demand for schooling, and the resulting increased enrollments have
overstretched the country’s resources. Most schools, especially secondary schools, do not even
have the basic resources, especially for teaching and learning science (Lungu, 2005). Therefore,
TALULAR innovation appears to be a promising alternative solution to the problem of shortage
of resources for teaching and learning science in schools. It is, therefore, vital that teachers
adopt, and more importantly, implement the innovation in their classrooms. Appropriate
strategies that are founded on theoretical propositions should, therefore, be utilized to enable the
ministry of education through its curricula and professional development agencies to facilitate
the diffusion, adoption and implementation of TALULAR innovation among science teachers.
Rogers’ diffusion of innovations theory is one such theory that offers valuable information that
could be used to best determine and understand factors that would facilitate the adoption and
implementation of TALULAR. However, a review of literature apparently shows that no study
based on diffusion of innovations theory has been conducted to determine important facilitating
factors in the implementation of TALULAR amongst secondary school teachers in Malawi, let
alone among secondary school science teachers.
Theoretical framework: Rogers’ Diffusion of Innovations Theory

The theory guiding this proposed study is Rogers’ diffusion of innovations (DOI) theory. This theory was formalized by Everett M. Rogers in his first publication in 1962. As far as DOI theory is concerned, he is the most cited author (Yates, 2001). According to Rogers (1995), “diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system” (p.5). He defined an innovation as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption” (Rogers, 1995, p. 11). Individuals in the social system judge an innovation by the perceived attributes or characteristics it possesses, and these attributes help to predict the rate of adoption of innovations (Rogers, 2003). The five main and distinct innovation attributes according to Rogers’ DOI theory are: relative advantage, the degree to which an innovation offers advantages over other innovations or present circumstance; compatibility, the extent to which the innovation fits or aligns with prevalent values, previous experiences or ideas, and needs of clients in the social system; complexity, the extent to which an innovation is considered difficult to learn and utilize; trialability, the degree to which an innovation can be tried out on a small scale; and observability, the degree to which outcomes resulting from use of a new idea are visible to other clients. Innovations that are perceived as having greater relative advantage, compatibility, trialability, observability, and less complexity have a more rapid rate of adoption than their opposites (Rogers, 2003). Rogers’ DOI theory offers valuable information in understanding why some innovations are adopted at an increasingly faster rate than others, and why others are rejected even though benefits may be obvious. While numerous studies have used perceived attributes of innovations as factors in innovation adoption, over the past years the perceptions of innovations have also been found to be important factors in the implementation of
a wide range of innovations. In this study, the perceived attributes of innovations will be used to examine secondary school science teachers’ perceptions of TALULAR innovation and their value in predicting the level of implementation of this innovation as an instructional tool among teachers in Malawi’s public schools.

Assumption of the study

According to Rogers’ diffusion of innovations theory, implementation presupposes adoption. A literature review shows that two studies, even though their focus was not on TALULAR, revealed some information about this innovation. A survey among primary school teacher trainers (tutors) in teachers’ colleges in Malawi showed that although the innovation was used less frequently, tutors had a positive attitude toward the innovation and acknowledged its potential benefits (Kadzera, 2006). In the same vein, Kalande (2006), in her qualitative case study, reported that primary school science teachers in Malawi also acknowledged the potential benefits of the innovation even though it was used less frequently in their instructional practices. Although these studies are limited in their scope and did not look at secondary school science teachers’ use of and views about the innovation, they do provide some useful insights into how potential adopters view the innovation. Therefore, the assumption of the study is that teachers in general and secondary school science teachers in particular, have adopted the innovation.

Delimitation

This study focused on the perceived characteristics of innovations as determinants of the level of TALULAR implementation. It did not focus on adoption of innovations especially on comparisons of adopter categories based on individual innovativeness for a number of reasons. First, there is high teacher turnover effect in the teaching profession in secondary schools in Malawi. Every year, many teachers leave the education sector either by changing their profession
or transferring from one school to another while at the same time new teachers continuously enter the system. In addition, a long period of time (about 10 years) had elapsed since the first diffusion campaign around 1997. For these reasons, it would not have been meaningful to study how some teachers were relatively earlier in adopting TALULAR innovation than others. Different teachers would have had different reference points about knowledge of the innovation and when they had adopted it, and to come up with an accurate proportion of teachers who had adopted or did not adopt the innovation at different times would have been difficult. The fact that a long period of time had elapsed since the first diffusion campaign, data collection on when and who had adopted or not adopted the innovation would have relied heavily on the memory of those who would have been present in schools. Such data could not have been accurate or reliable. For the same reasons, this study did not examine the actual innovation diffusion process in terms of communication channels and innovation-decision process. From the foregoing discussion, it was, therefore, deemed meaningful to study the level of use of the innovation by teachers who were available in the education system. This provided useful information on the level of implementation of the innovation and on factors that would be important in determining its use. It should also be noted that this study did not investigate the quality or effectiveness of the implementation process.

Due to limited resources and time, only science teachers in the northern region of Malawi constituted the study population. While it is recognized that TALULAR is important for almost all subjects, this study only focused on teachers who were teaching the following science-related subjects where the impact of shortage of resources was believed to be more significant: Physical Science, Biology, and Agriculture. Teachers in the following science subjects were excluded: Home Economics, Integrated Science, and Science and Technology. Integrated Science, and
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Science and Technology had been dropped from the national curriculum because they were not providing essential knowledge and skills required for further studies in science and engineering (Nyirenda, 2005). Home economics was not being taught in all schools; it was only being taught in a few schools that had the capacity in terms of teaching staff and other core resources like a well equipped kitchens or laboratories. Lastly, only teachers in government or government-aided secondary schools and community day secondary schools were included in this study. Teachers in private secondary schools were not included in this study because of unique differences between these schools and public schools in terms of educational financing and availability of resources.

Organization of the Proposed Study

Chapter 1 provides background information to the study, study assumptions, statement of the problem, theoretical framework, and delimitation. Chapter 2 includes a review of the literature related to this study. This chapter begins with a discussion of the main tenets of Rogers’ DOI theory, followed by an examination of empirical studies and other literature on innovation adoption and implementation in various disciplines and how these studies inform the current study. The third section of chapter 2 provides a brief overview of the status of education and science education in developing countries, specifically South of the Sub-Saharan Africa, and Malawi in particular. Chapter 2 ends with a discussion of the instructional innovation, called TALULAR, which the Ministry of Education in Malawi encourages teachers to utilize in their everyday instructional practices. Chapter 3 provides information about the methodology that was undertaken to answer the posited research questions. This chapter contains information on the research design, study population, sample and sampling procedures, data collection instruments and procedures, field testing of the survey instrument, and procedures for data analysis. In
chapter 4, findings of the study are briefly summarized. Finally, chapter 5 provides a discussion of the findings, summary, conclusions, and limitations of the findings. In this chapter practical implications of the findings are also discussed including recommendations for further research.

Definitions of Terms and Abbreviations

**CDSSs**: Community Day Secondary Schools. Schools formally called distance education centers.

**CSSs**: Conventional Secondary Schools. CSSs include government, and Grant-Aided Secondary schools. Grant-Aided schools are co-owned by both the government and religious institutions

**DOI theory**: Diffusion of innovations theory.

**JCE**: Junior Certificate of Education. Qualification students get after successfully completing form 2 or grade 10 in high school.

**MIE**: Malawi Institute of Education, a government arm of the Ministry of education responsible for curricula reforms.

**MoESC**: Ministry of Education Science and Culture.

**MSCE**: Malawi Senior Certificate of Education. Qualification students get after successfully completing form 4 or grade 12 in high school.

**PCIs**: Perceived characteristics of innovations. They are also referred to as perceptions of innovations, perceived attributes of innovations, or innovation attributes.

**Random errors**: Measurement errors in an individual’s score due to purely chance happenings such as guessing, environment distractions, lack of motivation, and scoring errors.

**Systematic errors**: Consistent measurement errors due affecting an individual’s score due to some particular attributes of a person or a test, such as errors due to an examinee’s visual or hearing impairment, or typos and ambiguous words on a test items.

**TALULAR**: Acronym for Teaching and Learning Using Locally Available resources.
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Chapter 2: Review of Literature

Introduction

This chapter includes a review of the literature related to this study. It begins with a discussion of the main features of Rogers’ diffusion of innovations theory, and highlights the following main elements: (a) the innovation and the perceived attributes or characteristics of innovations, (b) communication channels, (c) time in relation to the rate of adoption and the innovation-decision process, and (d) the social system. The next section examines empirical studies and other literature on innovation adoption and implementation in various disciplines and how these studies relate to the current study. Emphasis is placed on literature that deals with facilitating factors in innovation implementation, which is the focus of this study. Also summarized are the teachers’ demographic and employment variables as they relate to the observed variability in innovation adoption and implementation. The third section provides a brief overview of the status of education and science education in developing countries, specifically South of Sub-Saharan Africa, and Malawi in particular. This chapter concludes with a discussion of the instructional innovation called TALULAR, which the Ministry of Education in Malawi encourages teachers to integrate in their classrooms.

Rogers’ Diffusion of Innovations (DOI) Theory

Diffusion of innovations (DOI) theory was formalized by Everett M. Rogers in his first publication in 1962, now in its fifth edition. As far as DOI theory is concerned, he is the most cited author (Yates, 2001), and an intellectual leader who provides a comprehensive discussion of the theory. For this reason, this study draws heavily from Rogers’ DOI theory. His theoretical propositions, particularly the PCIs, guided this study. Diffusion of innovations is a social process and aids in conceptualizing why some members of a social system adopt or reject
innovations at a given point in time (Chapman, 2003). The focus of diffusion research centers on the conditions which increase or hamper the likelihood that an innovation will be accepted by targeted organizational members. Diffusion studies were originally typical in areas such as rural sociology, anthropology, and extension work in agriculture (Evans, 1968). Over the past decade, however, such studies have proliferated and are being conducted in numerous fields and contexts to understand change efforts associated with introduction of new ideas. Surry (1997) provided three reasons in support of the value of studying and employing diffusion theory in the field of instructional technology. First, he argued that understanding of factors that affect adoption of innovations will enable instructional technologists to predict and explain factors that either hinder or facilitate the diffusion of their educational processes or products. Second, understanding of the processes associated with innovations and their diffusion will better position instructional technologists to work effectively with individuals who have a stake in innovation adoption. Third, knowledge and understanding of diffusion theory would enable instructional technologists to come up with meaningful theoretical models that would better contribute to the understanding of the diffusion and adoption processes. The DOI theory has a close relation to the TALULAR and will provide a useful framework for studying its implementation by secondary school science teachers in their classrooms in Malawi. What follows is a brief discussion of important components and features of the theory.

According to Rogers (1995), “diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system” (p.5). Rogers pointed out that diffusion is facilitated by a unique type of communication that is not unidirectional, but one that seeks to attain mutual understanding through the creation and sharing of information by members of the social system to reach a unified goal. This implies that the
innovation adoption patterns exemplified by individuals in the social system are a manifestation of the nature of the communication flow (Attewell, 1992). Rogers and Shoemaker (1971) defined adoption as a decision to optimally utilize the innovation as the most desirable course of action accessible. While adoption could be manifested by overt behavior in the lives of targeted organizational members, the decision to adopt is mainly a mental process. The rate of adoption is a measure of speed by which a new idea is adopted by target organizational members, and is often determined by the time it takes for a certain proportion of users to make full use of the new idea (Rogers, 1983).

As evidenced in the definition of diffusion above, Rogers (1995) identified four main elements in the diffusion of innovations that may influence the adoption of an innovation: (a) the innovation itself, (b) communication channels, (c) time, and (d) the social system.

The innovation

Rogers (1995) defined an innovation as “an idea, practice, or object that is perceived as new by an individual or other unit of adoption” (p. 11). It should be understood that “newness” of the idea in this case is determined by targeted potential adopters of such an idea and not otherwise. Van de Ven (1986) shed more light on how ‘newness’ of an idea should be conceptualized in relation to innovations when he noted that, “as long as the idea is perceived as new to the people involved, it is an "innovation," even though it may appear to others to be an "imitation" of something that exists elsewhere” (p.592). Rogers further observed that the manner in which potential adopters consider an innovation as new significantly determines their attitudes toward it.

Individuals in the social system judge an innovation by its perceived attributes or characteristics it possesses and these attributes help to explain the rate of adoption of innovations
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(Rogers, 2003). As noted and defined in chapter 1, these five attributes are: Relative advantage, compatibility, complexity, trialability, and observability. According to Rogers (2003), innovations that are perceived as having greater relative advantage, compatibility, trialability, observability, and simplicity have a rapid rate of adoption than their opposites. The relative advantage and observability of an innovation relate both to immediate and long term socio-economic benefits arising from use of the new idea, while compatibility, complexity, and trialability are a measure of the ease with which clients can learn about and use an innovation (King & Rollins, 1995). Holloway (1977) found that the wish to gain social status (also called status seeking or status conferring by Rogers) was an additional characteristic that influenced adoption of an educational innovation by most members of the social system. However, Rogers (2003) noted that this feature has not been extensively studied and verified in most diffusion studies and suggested that this could be due respondents’ reluctance to admitting that securing social status associated with an innovation was the motivating factor for its acceptance. In this regard, it is important that change agents of an innovation must understand how individuals in the social system perceive innovations so that important steps could be taken to alter or utilize such perceptions in order to speed up the rate of the adoption process.

Communication channels

Rogers (2003) viewed communication channels as means of getting messages from one potential adopter to another in the social system. The two main important communication channels are mass media and interpersonal channels. Mass media channels are more effective in creating awareness knowledge of new ideas to members of the social system, and interpersonal channels, which involve face-to-face interactions, are more effective in influencing individuals to decide to adopt or reject an innovation by altering their attitudes toward it (Rogers, 2003; Rogers
& Scott, 1997). It should be noted that individuals do not adopt innovations based on evaluative judgments founded on theoretical or empirical evidence provided by experts; rather they do so by evaluating new ideas on the basis of subjective evaluations of immediate colleagues who adopt the new idea earlier than themselves (Rogers, 2003; Rogers, et al., 1997). A majority of individuals adopt an innovation through modeling and imitating their near peers (Rogers, 2003). Consistent with the observability attribute, the more charismatic the person providing the role model, the greater the probability that a good number of individuals targeted for the innovation will develop favorable attitudes toward the new idea and will eventually adopt it (Sanson-Fisher, 2004). Rogers (2003) identified a concept known as homophily, which has significant impacts in fostering innovation acceptance among targeted end users. He defined homophily as the degree to which two or more interacting individuals are similar in certain attributes such as education, socioeconomic status, and values. Rogers also observed that homophilous members also belong to the same social group, live or work near each other, share common interests, and share common meanings and mutual language. Homophily is a very important concept to consider in choosing change agents in order for communication among individuals to be fruitful regarding innovation awareness, development of favorable attitudes toward the innovation and change process, and elicitation of observable behavioral change among members of the social system (Rogers, 2003).

*Time*

Time is the third element in the DOI identified by Rogers (2003). Time factor is involved in the diffusion process in three different ways: (a) in the innovation-decision process, (b) in innovativeness of an individual or unit of adoption, and (c) in the rate of adoption of an
innovation. The rate of adoption is measured by the number of individuals in the social system who adopts an innovation within a specified duration of time.

*The innovation-decision process.* Rogers (2003) described the innovation-decision process in the following way:

The innovation-decision process is the mental process through which an individual (or other decision-making unit) passes from first knowledge of an innovation, to the formation of an attitude toward the innovation, to a decision to adopt or reject, to implementation and use of the new idea, and to confirmation of this decision. (p.20)

Rogers and Scott (1997) also observed that members of the social system seek information at each stage of the decision process with the goal of minimizing the uncertainties about the projected consequences associated with the new idea. Every member of the social system progresses through the innovation-decision process that usually follows five sequential steps as postulated by Rogers (2003):

1. An individual acquires awareness about the proposed innovation and has some idea of its functionality and capacity to solve problems (*knowledge* stage).

2. An individual is persuaded about the advantages and disadvantages of the innovation, and forms either a favorable or unfavorable attitude toward it (*persuasion* stage).

3. An individual engages in activities that lead to a choice to either adopt or reject the new idea (*decision* stage). This may involve attending workshops, peer-peer or peer-expert discussions.

4. An individual puts an innovation into use and incorporates it in the daily activities (*implementation* stage).
5. An individual evaluates the results of an innovation-decision that has already been made, and there is a chance that he/she may decide to overturn the earlier decision (confirmation stage). An individual may compare what happens in terms of costs and benefits to his near peers who had earlier on either adopted or rejected the decision, and if he continues using the new idea, he may even promote it to others (Rogers, 2003).

It is evident that one of the major obstacles to the innovation-decision process is uncertainty, and Rogers emphasized that during the innovation decision process, and especially during the persuasion and decision stages, individuals are very much interested in information they can use to decrease uncertainties about the innovation. As Orr (2003) observed, for most individuals, the innovation-decision process relies heavily on the innovation-decision of fellow potential adopters, and their decision is made after a thorough cost-benefit analysis where uncertainties are seen to be the major obstacle to decision-making.

**Innovativeness.** Innovativeness is defined as “the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a social system” (Rogers, 2003, p. 22). Rogers classified individuals in the social system on the basis of their innovativeness into five adopter categories: (a) innovators, (b) early adopters, (c) early majority, (d) late majority, and (e) laggards. According to Rogers (2003), these adopter categories were depicted based on empirical market data, and categories are compared using characteristics of the bell-shaped normal distribution and partitioned by the mean and standard deviation as shown in Figure 1. The categorization of adopters, according to Rogers, represents taxonomy of individuals in the social system based on their innovativeness, which is measured by time at which a certain proportion of members of the social system adopt an innovation. Empirical evidence also shows that adopters in the same category exhibit common characteristics.
and values related to innovation adoption (Brancheau & Wetherbe, 1990; Rogers, 2003).

What follows is a summary description of some dominant characteristics of each adopter category based on Rogers (2003):

a) **Innovators.** These are the first few (2.5 %) members of the social system to adopt an innovation. These individuals are venturesome, have tremendous interest in innovations and actively seek information, are risk-takers, and control sufficient monetary resources to deal with the possible loss resulting from the unprofitable innovation. They have higher socioeconomic status, are more educated and able to understand complex technical knowledge associated with the innovation, and are able to cope with high levels of uncertainty associated with an innovation at the time of adoption. Innovators play a critical role in the adoption and diffusion of innovations as they are the first members to bring new ideas into their social system.

b) **Early adopters.** These are the next 13.5% potential innovation users who are more integrated into the social system than innovators. This group comprises members regarded as opinion leaders in the social system and it is from this group of individuals that potential adopters seek information and advice about an innovation. They serve as role models and are highly regarded by other potential adopters who must check with
them first before making any decisions to adopt or reject the new idea. Early adopters thus make cautious innovation decisions to maintain the respect other members have for them. Their adoption of an innovation is perceived as a rubber stamp of approval by their peers, and they are targeted by change agents to expedite the diffusion process through their strong interpersonal networks. Once they adopt the new idea, the critical mass is triggered; that is, their adoption represents the “starting point at which enough individuals in a social system have adopted an innovation so that the innovation’s further rate of adoption becomes self-sustaining” (Rogers, 2003, p. 344).

c) *Early majority.* This group forms the next 34% of potential adopters of the innovation and they are rarely perceived by others as opinion leaders. This group interacts frequently with their peers and are willing to adopt but will deliberate for some time before they fully adopt the innovation.

d) *Late majority.* These are the next 34% of potential adopters. The group is skeptical and cautious in their approach to adopting an innovation and they wait until after most of their colleagues do so to make sure uncertainty levels are reduced. Their adoption of an innovation is driven primarily by the growing peer pressure and in some cases is influenced by economic gains.

e) *Laggards.* This is the last 16% of potential clients to adopt a new idea. This group of adopters possesses visually no opinion leadership and interacts primarily with others who are perceived to be adhering to traditional ways of doing things. They tend to be suspicious with innovations and change agents, and their decisions are influenced by what has been done in the past.
It is evident that individual innovativeness is influenced both by an individual’s characteristics and by the nature of the social system to which the individual belongs (Rogers, 2003). Rogers and Singhal (1996) pointed out that only a few innovators are willing to adopt an innovation in its very early stage of inception. They maintained that when these innovators begin to communicate the innovation to their peers, the rate of adoption begins to increase, and finally diffusion decreases to include a small proportion of laggards. From the various adopter categories and associated characteristics, it can be argued that individual innovativeness is related to adopters’ perceived innovation characteristics. Yi, Fiedler, and Park (2006) examined two alternative models where the role of individual innovativeness was theorized to be either a moderator variable of the effects of an innovation’s ease of use, usefulness, and compatibility on one’s use intension, or as a direct determinant of innovation characteristics. Using a survey approach, they investigated 222 health care professionals’ adoption of personal digital assistants (PDAs) under different adoption contexts. The findings consistently showed that individual innovativeness is a direct determining factor of the perceived characteristics of innovations. Conceptually, one would expect innovators to perceive an innovation as having greater relative advantage, compatibility, and being less complex to understand and use. Contrary to Rogers’ five classifications of adopter categories in which the classification was based on the timing of adoption, Bass (1969), in the development of the Bass Model, had only two categories: innovators (defined in the same way as Rogers) and imitators (a combination of Rogers’s early adopters to laggards). Bass argued that when Rogers defined innovators as the first 2.5% of adopters, his definition was arbitrary. On the contrary, the distinction between innovators and imitators, according to Bass, was made on the basis of the buying influence. Innovators adopt innovations exclusively due to external influence from mass-media communication channels.
while imitators are influenced internally by word-of-mouth or interpersonal communication (Mahajan, Muller, & Bass, 1990). In a study that surveyed online buying practices of 412 individuals, and the adoption of PDAs by 222 healthcare professionals, Yi et al. (2006) found a significant qualitative gap between characteristics of adopters and early majority. By categorizing potential adopters into only two groups (innovators and imitators), the Bass Model may overlook unique individual characteristics important in understanding the adoption of innovations.

Rate of adoption. The third way in which time is involved in diffusion is in the rate of adoption. Rogers (2003) observed that “when the number of individuals adopting a new idea is plotted on a cumulative frequency basis over time, the resulting distribution is an S-shaped curve” (p.23), as depicted in Figure 2. At take-off of an innovation, there few adopters are the innovators, and the curve rises slowly. The curve then speeds up until it reaches a steady rate as the remaining laggards finally adopt the innovation. When most or all individuals in the social system have adopted an innovation, diffusion is said to have reached a saturation point (Jacobsen, 1998). Another concept that is of interest in understanding the diffusion process is the critical mass. As already pointed out, this is a point where an adequate number of individuals have adopted an innovation such that further rate of adoption becomes self-sustaining (Rogers, 2003). Rogers also observed that while the S-curve describes the characteristics of successful innovations, it should be noted that such curves differ from one innovation to another.

The social system

The social system is the fourth main element in Rogers’ diffusion of innovations. It is defined as an aggregate of interrelated units working cooperatively to achieve a common goal (Rogers, 2003). Rogers further explained that units of the social system encompass individuals, informal
groups, organizations, and subsystems within the organization. According to Rogers, there are four elements of the social system that affect the diffusion of innovations: (a) social structure, (b) norms, (c) opinion leadership, and (d) change agents.

The social structure. As pointed out in the preceding sections, individual innovativeness is not only influenced by characteristics of each individual member in the social system but also by the nature of the society in which the individual belongs. According to Rogers (2003), social structure is a distinctive and stable arrangement of units that define social relationships among members of the social system. Accordingly, social structure explains how members of the social system interact and live together, and it provides a framework for accurately predicting other people’s behavior. As already alluded to, homophily plays a vital role in how these individuals interact and communicate innovation information. Usually, homophilous members will tend to group together to create communication structures, communicate more frequently, and have a greater influence on each other’s behavior (Rogers, 2003). One example provided by Yates (2001) is about teachers and administrators. Teachers interact more frequently and more freely with each other than with school administrators or principals, and when some teachers adopt an
innovation, it is predictable that others will follow suit. Rogers also noted that in the social structure, people on top of the hierarchy who have power and status will tend to force subordinates to adopt new ideas. As a result, it is predicted that the rate of innovation adoption is faster when potential adopters’ decisions to adopt have been influenced or made by someone in authority than when the decisions by individuals are optional or voluntary (Rogers, 2003). However, Rogers also warned that authoritative decisions to adopt an innovation may only help initial adoption and may decrease the likelihood that it will be implemented and routinized.

**Norms.** Norms are established behavioral patterns shared by members of a social group (Rogers, 2003). Norms affect diffusion in that they “define a range of tolerable behavior and serve as a guide or standard for the behavior of members of the social system” (Rogers, 2003, p. 26). For Rogers, if the innovation aligns well with the norms of the social system, there is a high probability that it will be adopted; otherwise it will be rejected.

**Opinion leaders.** Opinion leadership is defined as “the degree to which an individual is able to influence other individuals’ attitudes or overt behavior informally in a desired way with relative frequency” (Rogers, 2003, p. 27). Rogers pointed out that leaders influence the adoption and diffusion of new ideas by being sources of advice and information about an innovation to most other members in the social system. He also highlighted attributes that are sufficient to regard one as an opinion leader. For instance, one’s perceived technical competence, social accessibility, and conformity to social norms are benchmarks for members to secure and maintain the informal position of opinion leadership. Rogers further observes that opinion leaders demonstrate the innovation behavior and are role models to other potential adopters. They tend to be more innovative if social norms are oriented to change. Other characteristics that distinguish opinion leaders from other members of the social system include the following: (a)
they have more exposure to external communication, thus they are cosmopolite; (b) have higher socio-economic status; and (c) are more innovative (Rogers, 2003). While opinion leaders have tremendous positive influence on the beliefs and behavior of their peers, they may also influence others negatively if the innovation does not have their support, especially if the innovation is either not appealing or has ambiguous goals (Locock, Dopson, Chambers, & Gabbay, 2001).

*Change agents.* Rogers (2003) defined a change agent as “an individual who influences clients’ innovation-decisions in a direction deemed desirable by a change agency” (p. 366). According to Rogers, change agents bridge the communication gap between a change agency, where experts of innovations are based, and the potential clients. Change agents work through opinion leaders in order to close the heterophily gap between themselves and clients (Rogers, 2003). Rogers also highlighted a number of factors associated with change agents that contribute to their success. A brief description some of these factors follows. (a) *Change agent effort.* A change agent’s success in influencing members of the social system to successfully adopt the innovation depends upon the level of effort on the part of the change agent to contact clients. (b) *Client orientation.* Successful change agents influence the adoption of innovations when they consider clients’ needs, have a higher level rapport with clients, place great importance on feedback to clients, and consequently have higher credibility in the eyes of clients. (c) *Compatibility with clients’ needs.* When the diffusion is not in conflict with clients’ felt needs change agents are likely to succeed in influencing the adoption of the innovation. (d) *Change agent’s empathy.* A change agent’s increased empathy and a more positive relationship with clients play significant role in successfully influencing clients’ adoption of an innovation. (e) *Use of para-professional aides.* Despite having less technical expertise, para-professionals (individuals who are at a lower level than fully professional change agents, and who are more
homophilous with lower status clients) are more suitable as change agents because of their personal acceptance in the eyes of most. (f) **Change agents’ credibility.** An ideal change agent would be the one with a balance of both heterophily and homophily, and a balance of competence credibility and safety credibility (perceived trustworthiness). In general, change agents’ success in influencing clients to adopt a new idea is positively related to potential adopters’ perception of a change agent’s credibility. (g) **Use of opinion leaders.** A change agent’s success in effectively securing clients’ adoption of new ideas is positively related to the degree to which he or she works through opinion leaders. However, Rogers (2003) argued that concentrating too much on opinion leaders may erode their credibility if they become too innovative because innovators are considered by potential adopters as aberrant from established norms of the social system. (h) **Use of demonstrations.** When new ideas are demonstrated, it helps potential adopters see how best such ideas could be successfully utilized under conditions similar to their own (Rogers, 2003). In addition, he also reiterated that demonstrations not only reduce uncertainties associated with innovations, but they also provide potential adopters with an opportunity and context to evaluate the innovation. Rogers further observed that the ability of individuals to evaluate innovations facilitates the adoption process.

**Summary**

Rogers’ diffusion of innovations theory offers a valuable framework for understanding factors that influence the acceptance and rejection of innovations. The theory postulates four main elements in the diffusion process that influence the adoption of new ideas: (a) the innovation itself, (b) communication channels, (c) time, and (d) the social system. Rogers argued that these elements are manifested in the diffusion processes of every single innovation. The innovation-decision process is a mental process through which potential adopters progress from
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the point of awareness of the innovation to adoption, implementation and confirmation. These
stages present critical points in the diffusion campaign and should guide change agents in
deciding the type of information to emphasize, and the communication channels to utilize to
decrease uncertainties associated with the innovation, thereby, hastening the rate of adoption and
eventual utilization of the innovation. For instance, mass media channels are most important for
creating awareness knowledge to a larger audience more quickly, while interpersonal channels of
communication are vital in altering potential adopters’ attitudes about the new idea as well as
their behavior. Potential adopters in the social system have varying characteristics that place
individuals in different adopter categories. These characteristics are important determinants of
how relatively early or late one is going to adopt a new idea. However, very few individuals
possess characteristics that enable them to adopt innovations as soon as they are launched.
Larger proportions of potential adopters are usually uncertain about the consequences associated
with new ideas and therefore wait until a larger proportion of their peers adopt them.

In addition, members of the social system judge an innovation by the perceived
attributes or characteristics it possesses and these attributes help to predict and explain the rate of
adoption of innovations. Innovations that are perceived as having higher relative advantage,
compatibility, trialability, observability, and simplicity, are predicted to have a higher rate of
adoption than their counterparts. Therefore, change agents have a greater responsibility in
utilizing workable communication channels and furnishing information that would help potential
adopters develop desirable perceptions to enhance adoption decisions. While Rogers’ DOI theory
is conceptually different from the technology acceptance model (TAM) proposed by Davis
(1989), they share some common features. For instance, complexity which is one of Rogers’
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perceived characteristics of innovations is closely related to perceived ease of use in TAM (Davis, 1989), and relative advantage parallels perceived usefulness (Moore & Benbasat, 1991).

According to the Rogers’ DOI theory, for change agents to succeed in securing adoption from targeted end users of an innovation they must, among other things, be emphatic, increase the contact efforts, demonstrate the utility of innovations, and utilize opinion leaders and other members of the social system who are more homophilous with targeted members. It is evident that securing adoption of new ideas is an intricate process that involves a number of sub-processes and requires coordination of all relevant elements of the entire social system. It is for this reason that securing adoption, and more importantly utilization of new ideas, is quite challenging. Rogers (1995) recognized this challenge when he noted the following:

Getting a new idea adopted, even when it has obvious advantage, is often very difficult.
Many innovations require a lengthy period (innovation-decision period), often many years, from the time they become available to the time they are widely adopted.
Therefore, a common problem for many individuals and organizations is how to speed up the rate of diffusion of an innovation. (p.1)

Adoption of innovations entails social change and attaining social change is not a simple process. However, knowledge of the mechanisms presented in Rogers’ DOI theory provides a basis for planning change efforts to ensure a successful innovation diffusion process.

Criticisms of Rogers’ diffusion of innovations theory

Like any other theory or model of innovation, Rogers’ DOI theory is not without criticisms, and such criticisms may highlight certain limitations of the theory. One of the criticisms leveled against Rogers’ DOI theory is about the pro-innovation bias. According to Rogers (2003), “the pro-innovation bias is the implication in diffusion research that an innovation should be diffused
and adopted by all members of a social system, that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected” (p.106). As a result of this bias, researchers are unable to look at diffusion of innovations holistically and fail to learn certain important issues such as end-users’ ignorance about new ideas, discontinuance, and other anti-diffusion programs aimed at preventing undesirable innovations (Rogers, 2003). In Rogers’ view, in order to better understand diffusion of innovations both potential adopters as well as rejecters should be included in research problems rather than focusing only on change agents who are pro-innovations (Rogers, 2003). The second criticism relates to individual blame. Most of the times individuals are held responsible for failing to adopt an innovation rather the system, which may be the one requiring improvement (Frambach, 1993; Rogers, 2003). Rogers pointed out that more often the variables that form part of diffusion studies in which researchers seek to investigate factors that predict innovativeness, fail to measure whether or not the system is at fault, but instead measure the success or failure of individual members in the system. Greenhalgh, Robert, Bate, MacFarlane and Kyriakidou (2005) further observed that this limitation comes about because it is relatively easier to study innovation adoption by individuals than otherwise. Lastly, defining individual innovativeness as a function of time fails to provide rich information about the individual underlying characteristics that are responsible for adoption behavior (Yi, Fiedler, & Park, 2006). These categories were mathematically derived and did not consider other relevant psychological variables in the original theory (Greenhalgh et al., 2005).

**Summary**

Among other things, the criticisms highlighted in the preceding paragraphs suggest that when innovations are successfully adopted or are rejected by members of the social system, it is important to understand the phenomenon holistically. Such a success or failure to adopt could
either be due to organizational failure in the planning and execution of the entire diffusion processes or due to resistance offered by potential adopters (individual failure), and the nature of the innovation itself. In its current form, Rogers’ DOI theory has taken into account the process of re-invention. While in the early stages of diffusion research adoption meant carbon copying the innovation, diffusion scholars now understand that end-users of innovations modify innovations during adoption and implementation processes (Rogers, 2003). Rogers further argued that individuals may re-invent an innovation so that it fits their needs or their prevailing contextual conditions. For Rogers, as long as re-invention retains core elements on an innovation, it should be considerable desirable.

Empirical studies on adoption and implementation of innovations

There have been numerous studies on adoption of innovations in various fields. Since this study focuses on implementation of innovations, a brief overview of some empirical studies related to innovation adoption will be provided. Then a more comprehensive discussion on implementation of innovations in light of Rogers’ diffusion of innovations will follow.

Brief overview of adoption studies

Extensive research has been done on the adoption of innovations especially in relation to the five attributes of innovations as factors in innovation adoption (Al-gahtan, 2003; Allan & Wolf, 1978; Boz & Akbay, 2005; Carter, 1998; Davis, 1989; Jacobsen, 1998; Martins, 2004; Pagani, 2006; Yates, 2001). According to Rogers (2003), the five perceived characteristics of innovations influence the rate of innovation adoption. In particular, innovations that are perceived to have greater relative advantage, compatibility, simplicity, observability, trialability will be adopted at a faster rate than their counterparts. Rogers’ argued that these five innovation attributes explain about 87% of variance in the rate of adoption of innovations. Rogers (2003)
contended that these variables are conceptually distinct, and his study findings and those by other scholars have consistently supported them as important determinants of innovation adoption. In a correlation study that sought to investigate the relationship between the five perceived attributes of computer technology innovation, and computer adoption and use by different knowledge workers in different public institutions across in Saudi Arabia, Al-Gahtani (2003) found that perceptions of relative advantage, compatibility, observability, and trialability were positively related to computer adoption and use, while complexity was negatively correlated with adoption of computer and its usage. These findings supported Rogers’ DOI theory that innovation attributes are important determinants of innovation adoption. Similar findings were also reported by Askarany, Smith, and Yazdifar (2007).

Allan and Wolf (1978) used secondary data initially collected by Wolf and Fiorino (1972) to examine the relationships between perceptions of innovations and educator’s adoption of a number of educational innovations. Using a post facto design, educators reported to have adopted various innovations were randomly selected. Except for complexity, which was found to be negatively related to adoption, all the remaining attributes were not significantly related to adoption. While these findings partly confirmed Rogers’ proposed relationship between innovation attributes and adoption, for the most part they contradicted the hypothesized relationships. In a related study that examined five characteristics of an educational innovation (Project Advance) that influenced its adoption by public schools, findings revealed that only the perceived relative advantage, compatibility, complexity (ease of use), and trialability had significant effects on its adoption (Holloway, 1975). Holloway’s findings were to a larger extent supported by findings of a study by Sooknanam, Melkote and Skinner (2002) who examined the relationship between teachers’ attitudes, perceived innovation characteristics and
adoption/implementation variables related to computer use in the classroom in Trinidad and Tobago. Using survey methodology, data were collected from 142 teachers who participated in a computer literacy workshop. Among the four perceived attributes (relative advantage, compatibility, observability and complexity) included in the study, only three (relative advantage, compatibility and observability) were significantly associated with teachers’ adoption of computers in their instruction. However, such findings contradicted those by Halloway (1975) who did not find perceived observability to be an important factor in facilitating the adoption of the innovation.

Martins, Steil, Jose, and Todesco (2004) conducted a quantitative study to identify factors that supported or impeded the adoption of the Internet as a teaching tool in language schools of Southern Brazil. Using a survey, they collected data from 92 language teachers who were responsible for instructional decisions in these schools. Of the five perceived characteristics of innovations, only observability and trialability were significant predictors of Internet adoption. While these findings partly supported earlier findings by Al-Gahtani (2003), Rogers (1995), and later findings by Askarany et al. (2007), they contradict earlier findings by both Allan and Wolf (1978) and Sooknanam et al. (2002).

Summary. This review of literature on adoption studies has revealed that Rogers’ five main perceived attributes of innovations that influence the rate of adoption have been well studied over the past years. Cross-comparison of study findings revealed inconsistent results in diffusion studies done in different contexts. While some findings have supported Rogers’ propositions, others have contradicted such propositions. Despite these inconsistencies, some attributes have been shown to be stable predictors of innovation adoption. In a meta-analysis study, Tornatzky and Klein (1982) showed that of the five perceived attributes of innovations,
the first three attributes: relative advantage (usefulness), compatibility, and complexity (ease of use) have been found to be the most stable or consistent predictor variables of innovation adoption. Other studies based on technology acceptance model (TAM), which is very similar to Rogers’ DOI theory, have also found inconsistent results on perceived usefulness and ease of use (Agawal and Prasad, 1997; Chau, 1996; Davis, 1989; Davis et al., 1989; Horton et al., 2001; Hu et al. 1999). However, perceived usefulness has been found to be a more stable determinant of technological innovation acceptance, and according to Davis (1989, 1993) and Adams, Nelson and Todd (1992), perceived usefulness is a stronger determinant of innovation usage than perceived ease of use.

Implementation studies

Introduction. The most important question about innovations in diffusion research today is how to attain successful innovation implementation once they have been adopted (Sooknanan et al., 2002). Surry and Ely (2002) also indicated that the trend in diffusion research seems to shift from innovation adoption towards important topics of implementation and institutionalization. Implementation is the fourth step of the five main steps in Rogers’ innovation-decision process. Implementation occurs when end-users put the innovation into use and integrate it in their daily activities (Rogers, 2003). Accordingly, Rogers clearly differentiated the stages leading to adoption of an innovation from the implementation stage as follows:

Until the implementation stage, the innovation decision process has been a strictly mental exercise of thinking and deciding. But implementation involves overt behavior change as the new idea is actually put into practice. It is one thing for an individual to decide to adopt a new idea, quite a different thing to put the innovation to use, as problems in exactly how to use the innovation crop up at the implementation stage. (p.179)
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Although Rogers hypothesized and confirmed the five distinct attributes or perceptions of innovations as determinants of innovation adoption, it can be hypothesized that such perceptions could be important predictors of innovation implementation. For instance, even at the implementation stage, adopters still possess certain levels of uncertainty associated with using the innovation despite having adopted it (Rogers, 2003). The following questions may arise among potential users during re-invention (redefining) and clarifying stages of implementation process:

a) Where to obtain the innovation? (b) What does it do? (c) How to make use of it or how does it work? (d) What are the likely problems or negative consequences emanating from its use, and how to resolve them? (e) In what way does the innovation fit with existing users’ knowledge, practices, needs, norms and values? (Rogers, 2003). Therefore, there is no doubt that the perceptions of innovation could be well developed and best understood during the implementation stage. From the preceding discussion, the hypothesis that the perceived attributes of innovation that predict innovation adoption could also significantly predict innovation implementation levels, seems legitimate.

Challenge of innovation implementation. Innovation implementation is so challenging that many adopting organizations and individuals fail to realize the optimal expected benefits of innovations usually due to failure to successfully implement the innovation and not necessarily due to failure of the innovation itself (Klein & Sorra, 1996). Klein et al. (1996) defined implementation as “the process of gaining targeted organizational members’ appropriate and committed use of an innovation” (p.1055). Klein and Knight (2005) expanded the above view of implementation by pointing out that if targeted organizational members use the new idea regularly, and in a consistent and committed manner, then one can say that they have succeeded at implementation. A number of challenges associated with innovation implementation have
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been well documented in literature. In the paragraphs that follow, prominent innovation implementation challenges highlighted by Klein and Knight (2005), and Klein and Sorra (1996) are reviewed.

First, problems of unreliability and deficiencies in design for technological innovations that are based on digital technologies such as computers and related software programs hamper innovation implementation. Second, many new ideas demand end-users to acquire new knowledge and skills to effectively use such ideas. Some targeted organizational members may find this process unpleasant or laborious. Third, decisions to adopt organizational innovations are often made by high-ranking personnel without the participation of targeted organizational members. End-users may resist the actual use of such innovations because of uncertainties’ associated with the innovation or because they are comfortable and want to maintain their status quo.

Fourth, usually expected benefits associated with innovation implementation may be observable after a longer period of time thereby casting shadows of doubt in the mind of the end-users about the actual benefits and perceived observability of results from using the innovation (Rogers, 2003). As noted by Klein and Knight (2005), organizations invest in innovations with the sole aim of realizing higher levels of performance or productivity, therefore, end-users and managers may experience undue panic to ensure that existing levels of performance or productivity, while implementing the innovation, are either maintained or improved. Klein and Knight (2005) observed that this may be the case as the implementation of new ideas may not only be time consuming and expensive but may also decrease performance especially during the early stages of the implementation process.
Fifth, poor innovation-value fit has been documented to be one of the stumbling blocks to innovation implementation (Klein and Sorra, 1996). Klein and Sorra (1996) defined innovation-value fit as “the extent to which targeted users perceive that use of the innovation will foster (or, conversely, inhibit) the fulfillment of their values” (p.1063). This is consistent with the perception of compatibility; the extent to which the innovation fits or aligns well with preexisting values, previous experiences or ideas, and felt needs of the clients in the social system (Rogers, 2003). Klein and Sorra (1996) indicated that educating targeted members about the need for and value of the innovation to the attainment of intended organizational goals is one way to promote good innovation-value fit. From the preceding discussion, and consistent with Rogers’ DOI theory, users perceptions of good innovation-value fit are likely to facilitate the innovation implementation.

Sixth, Klein and Sorra (1996) contended that apart from innovation-value fit as a facilitator of innovation implementation, the challenge for organizations is to establish a strong climate for innovation implementation. They described an organizational climate for innovation implementation as “targeted employees’ shared summary perceptions of the extent to which their use of a specific innovation is rewarded, supported, and expected within their organization” (p.1060). While the concept of climate for implementation appears broad and subsumes numerous aspects associated with innovations, the provision of the following to end-users helps create a strong implementation climate: (a) training to ensure skill acquisition, (b) post-innovation continued support services, (c) adequate time for users to learn to use the innovation, (d) feedback to concerns and complaints, (e) incentives and disincentives for use and non-use, and (f) access to the innovation (Klein & Sorra, 1996).
Empirical studies on innovation implementation. Due to the need for and value of innovation implementation as compared to innovation adoption, there has been increasing interest in studying innovation implementation over the past years. Sooknanan et al. (2002) conducted a quantitative study that examined the relationship between the implementation of computers as instructional tools in Trinidad and Tobago public schools and teachers’ attitudes and perceptions towards computers. Implementation was measured in terms of teacher satisfaction with computer usage, and computer utilization. Computer utilization was measured, among other things, in terms of acceptance, and frequency of use. Both attitudes and perceptions of innovations were found to be important factors related to innovation implementation. Similar findings were reported by Roa (1994) who also investigated the relationship between users’ attitudes towards computers and perceptions toward a national computer-communication network used by the Indian administrative system for national planning. While these two studies reported similar results, they differ in that the study done by Sooknanan et al. (2002) was conducted in educational context while that by Roa was conducted in a non-educational context. In addition, among the four perceived innovation characteristics used (relative advantage, compatibility, complexity, and observability), Roa found that all these were significantly associated with adoption/implementation of the innovation in agreement with later findings by Askarany, Smith and Yazdifar (2007) who also found a significant association between innovation attributes and implementation decisions for a cost and management accounting innovation, called Activity-Based Management (ABM), in a corporate organization. Sooknanan et al. (2002), on the other hand, did not find any evidence that complexity was related to innovation adoption and implementation contradicting with Rogers’ DOI theory where complexity of innovation is negatively related to innovation adoption. It should also be noted
that Askarany et al. (2007) used many attributes some of which were not clearly related to the five main attributes defined by Rogers (2003), and still more, some were either confounding or redundant. For instance, they used the following as distinct attributes of innovations: *The level importance of easiness of innovation, and the level importance of easiness of implementing innovation.* These attributes are almost redundant or confounding measures of the same attribute of the perceived complexity or ease of use. It was not clear whether the easiness factor was measured during trial phase or during the implementation of the innovation.

Findings of a study by Aiman-Smith and Green (2002), which in part sought to investigate how innovation attributes affected individual implementation outcomes in a corporate setting, complexity was found to be negatively related to satisfaction as a measure of implementation, and formal training was also related to implementation. However, this study used six attributes of technology some of which were not part of five main attributes specified by Rogers (2003), and one such attribute was the *speed to competence.* While Rao’s (1994) overall results supported the diffusion of innovations theory, they contradicted, in part, with the theory. Instead of finding a positive relationship between observability and innovation adoption/implementation variable, a significant negative relationship was found.

Hughes and Keith (1980) investigated the relationship between perceptions of an elementary science curricula and the extent of its implementation by teachers. In general, findings revealed that a significant relationship existed between the innovation attributes and the degree of implementation. However, no statistically significant relationship between the relative difficulty (complexity) of the science curricula and the degree of implementation was found. Such a finding was in sharp contradiction with findings by Rao (1994). The finding worth noting was that the perceptions of innovations accounted for 40.1% of the variance in the observed
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degree of implementation. This was quite a substantial proportion of accounted variance although it was lower than that hypothesized by Rogers (2003) in his DOI theory but higher than that found Goldman (1994). A number of limitations could be pointed out in Hughes’ and Keith’s (1980) study. First, a very small sample was used that would limit the generalization of findings. Scholars have recommended that the minimum ratio of subjects to number of variables in studies that utilize multiple regression analyses be at least 30: 1 or 40:1 in order for the results to be meaningful (Pedhazur, 1997). Second, the implementation of the innovation was investigated two years after the innovation was adopted by top management rather than by actual end-users, the teachers. As pointed out earlier, end-users are more likely to resist actual use of the innovation in this context (Klein and Knight, 2005), and longer periods (more than 2 years) may be expected before substantial implementation could be observed. This could also be the cause for the larger percentage (60%) of unexplained variance, which the authors were aware of.

In an explanatory study that investigated the extent to which attributes of innovative health services and activities had utility in explaining variations in the implementation of such services and activities in organizations (i.e. hospitals and health departments), Kaluzny and Veney (1973) found that attributes of these innovations accounted for 58%, and 50% of the variance in implementation of health services in hospitals, and in health departments, respectively. They concluded that such findings provided evidence that attributes were important factors in health services innovations’ implementation. For this study, authors operationalized five attributes: (a) return on investment, (b) cost attributes, (c) risk or divisibility, (d) communicability, and (e) congruence. Risks were defined similar to trialability, return on investment and costs attributes similar to relative advantage, and congruence similar to compatibility. These were much similar to Rogers (2003) innovation attributes, however,
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communicability was defined in terms of complexity and clarity of results, subsuming Rogers’
two distinct attributes: observability and complexity. Although a few attributes used in this
study seemed to be comparable to attributes of innovations as operationalized by Rogers and
Shoemaker, (1971), they were conceptually a very different set of attributes and the study cannot
be considered as one based typically on DOI theory as developed by Rogers and Shoemaker
(1971) and Rogers (2003). In fact, one of the criticisms of diffusion of innovation studies
investigating attributes of innovations as factors in implementation is the operationalization of
too many attributes (Tornatzky &Klein, 1982). Tornatzky et al. (1982) underscored problems in
using too many attributes and the need to reduce the number of attributes as follows:

The innovation characteristics field seems to suffer from the seemingly constant
discovery and/ or re-naming of innovation characteristics. We came across more than
thirty innovation characteristics in the course of our review. While the identification of
“new” innovation characteristics (e.g., risk, and impact on work relationships) may be
useful, there is real need to determine the empirical independence of these characteristics
and to eliminate redundant characteristics. (p.41)

In a meta-analysis involving 75 studies on innovation attributes and their relation to
adoption and implementation, the attributes of compatibility, relative advantage, and complexity
were found to be the most consistent regarding the relationship to innovation adoption-
implementation (Tornatzky et al.,1982). However, Tornatzky et al. bemoaned the lack of
appropriate methods in these studies. They observed that most studies were postdictive rather
than predictive since the assessment of attributes of innovations was done after the fact rather
than prior to or concurrent with a decision to adopt such innovations. In addition, they
maintained that ideal studies should measure adoption and implementation as dependent
variables rather than the binary yes/no adoption decision as it fails to account for important behavioral variations across potential adopters in different settings. In the same vein, they argued that the examination of one or a few attributes in studies makes it hard “to compare the predictive power of various attributes unless the attributes are examined and compared within a single study based on the same respondents” (p.32). It was Goldman (1994) who, in his predictive study, empirically derived and used the five main attributes of innovations as predictors of implementation levels in the diffusion of a National March of Dimes Birth defects Foundation’s (MOD) Campaign for health babies in a voluntary nonprofit health organization setting. While all the perceptions of innovation survey subscales correlated with the implementation score, trialability and compatibility with organizational experience subscales were not significantly associated with implementation. Using multiple regression analysis, collectively, the perceptions of innovations significantly accounted for 18% of variance in implementation. However, only simplicity made a significant independent contribution to the prediction of innovation implementation. It should be noted that although the perceptions of innovations as empirically derived in this study corresponded to Rogers’ five main innovation attributes to a larger extent, the use of attributes of compatibility with chapter needs, and compatibility with prior organizational experience as unique attributes seems to be a cause for concern regarding the effectiveness of the instrument development and validation process.

McCormick, Steckler and McLeroy (1995) conducted an experimental study to determine the degree of implementation of school health education curricula, to identify factors that fostered or hampered implementation, and to examine the association between adoption and implementation phases of the diffusion process. Subjects were all teachers in the selected school districts that were eligible as health teachers. They found that the size of the organization and
training were the strongest predictors of curricula implementation. In addition, they also found that a conducive organizational climate within the school districts added to the improved implementation. The strength of this study was the use of multiple measures of implementation, in addition to measuring implementation longitudinally at two separate time periods (3-6 months after training and after 1 year). However, the sample (school districts) used in the experimental and control groups were rather small, a limitation that the authors also acknowledged. The other limitation is that the validity and reliability of the measures of implementation were not reported and the reader has no information to judge the validity and reliability of the findings. This study differs from other studies reviewed here in that it focused on organizational factors in the diffusion of innovations rather than on characteristics of innovations as perceived by end-users. A later study by Bruque and Moyano (2007) confirmed findings by McCormick et al. (2007) even though Bruque’s et al. (2007) case study was conducted in a non-educational setting involving family and cooperative firms.

Studies have also compared differences in the levels of contribution in accounting for variance in innovation implementation by different factors from different theoretical models. For instance, Yetton, Sharrma and Southon (1999) sought to unify two competing information systems (IS) theories about implementation by developing a model in which contributions of innovation attributes and implementation process theories on implementation were compared. Implementation process theory developed by Zmud (1984) is based on the premise that targeted organizational members in the innovation diffusion process resist adoption unless supported by their managers. Yetton et al. (1999) defined implementation process as the “organizational effort to diffuse an IS innovation within a user community” (p.55), and it was measured in terms of managerial behavior (support and urging) and organizational support (such as physical access
and training). The other variables that were measured as factors in implementation success included individual characteristics (innovativeness and skill, and performance) and informal support such as network support. Innovation characteristics were found to have a strong positive main effect or contribution on implementation success and significantly accounting for 27% of variance, while implementation process, individual characteristics and informal support had no significant main effect on implementation success. Even though this study offered cumulative evidence on the importance of innovation attributes in influencing implementation, the attributes used (such as task relevance, and task usefulness) did not comprehensively cover the five main attributes according to Rogers’s DOI theory.

A further review of related diffusion studies revealed a number of descriptive case studies on innovation related to innovation implementation. Meyer and Goes (1988) analyzed results of a 6-year study that examined the assimilation (or adoption) of innovations in 25 community hospitals in the USA. The study was based on a basic theoretical model whose premise was that innovation assimilation in organization is a process of progressively a series of “decisions to evaluate, adopt and implement new technologies” (p. 897). This model was based on other previous innovation models by Zaltman and Holbeck (1973) who conceptualized the following stages in the innovation assimilation process: (a) matching innovation to opportunity, cost (b) benefit analysis, (c) adoption or rejection, and (d) reutilization. Using a multi-method case study utilizing observation, document analysis, interviews, and questionnaires, the study sought to test following hypotheses: (1) that attributes of innovations (medical risk, needed skill and observability) would be independently related to innovation assimilation, (2) that organizational features or contextual attributes (size; complexity and market strategy; leadership variables such as tenure, educational level and recency of education; outer context (organization environment)
such as level of urbanization and affluence) would be independently associated with adoption, and (3) innovation-organization interactions such as the interaction between compatibility of the innovation and skill. Using correlations as a measure of associations between variables, all the hypotheses were generally supported, with the assimilation of a medical technological innovation being highly dependent on innovation attributes, and the independent association between the innovation and organizational and leadership variables being weak. Using hierarchical regression analysis, the variables collectively accounted for 77% of the variance in assimilation of the innovation. The findings, in part, were in support of Rogers’ diffusion of innovations theory, and later findings by (Askarany et al., 2007; Rao, 1994). However, Meyer and Goes’ (1988) study did not draw explicitly on Rogers’ DOI theory. For instance, of the five main innovation attributes, only the perceived risk (which is related to relative advantage), observability, and skill needed to utilize the innovation (which is related to either complexity or compatibility) were used as measures of innovation perceptions.

In a qualitative case study by Morris (1985), which attempted to determine why teachers failed to implement a new teaching approach that emphasized pupil involvement and heuristic learning style as recommended by curriculum planners, findings revealed that teachers not only evaluated the innovation in terms of efficiency in covering the syllabus and its congruency with expectations of significant others, but also evaluate it based on the extent of desirability and undesirability of consequences arising from its usage. In a similar study by Dass (2001) that investigated teacher concerns associated with implementation of a science instructional innovation (constructivist approach) in K-12 classrooms as advocated by The Iowa Chautaugqua Program (ICP), teachers expressed, among other things, the following concerns: (a) the innovation demanded more time to organize, plan, locate resources, and assess students than the
textbook approaches they were used to, (b) teachers found difficulties to effectively implement the innovation because they did not have the requisite knowledge and skills, (c) the innovation demanded learning new ways of assessment methods and wanted to see corresponding and holistic changes in existing assessment procedures within the entire school system in order to increase the perception of compatibility to motivate them to fully implement the approach, (d) the approach demanded deviations from the sequence that they would normally follow in covering curricula topics, which was a challenging task, and (e) teachers were also not sure whether the new approach would result into improvements in the SAT scores, which was the biggest concern for teachers. It is evident that findings of the above two studies by Morris (1985) and Dass (2001) provide support for the importance of perceptions of relative advantage, and compatibility with existing practices and needs in innovation implementation. While such findings help us to richly understand factors associated with innovation implementation, they only reveal a section of a broad spectrum of possible factors that potentially impact implementation decisions especially if viewed in light of the five main perceptions of innovations according to Rogers’ DOI theory.

Lastly, the work of Ely (1990, 1999a, 1999b) has made important contribution to the study of innovation implementation in the field of instructional technology. Inspired by the work of Mayhem (1975) on facilitating conditions for innovation implementation, in 1976 he came up with a list of factors that appeared to account for innovation implementation. These factors are commonly referred to as the eight conditions that facilitate change efforts in innovation implementation. These conditions are: (1) dissatisfaction with status quo, (2) existence of knowledge and skills required for innovation implementation, (3) availability of resources, (4) availability of time (company or organizational times, as well as personal time), (5) rewards
and/or incentives (a stimulus to act or something given for attaining desired performance standard), (6) participation (shared decision-making among all those who have a stake in the implementation success), (7) commitment (demonstration of firm and overt evidence of endorsement and untiring support from high-ranking personnel), and (8) leadership. Fundamental to these conditions, is the premise that the presence of the eight conditions is necessary for the implementation of change efforts once an innovation is introduced and adopted. Ely (1990) conducted a status study which among other objectives, sought to determine factors that contributed to the acceptance or rejection of educational technology innovations, and to make cross-cultural comparisons of educational innovations in Indonesia, Chile and Peru in order to determine the robustness of the concepts in other cultures. Data were collected using questionnaires, interviews and document analysis. Findings confirmed the presence of most of these conditions that facilitated change in all these countries. While dissatisfaction with the status quo, the need for knowledge and skills by the users, the need for resources, the need for leadership, and the commitment to the innovation were present and strong in all countries, other conditions such as, the need for rewards and incentives and participation were not uniformly strong across countries. For example, the importance of rewards or incentives was strong in Indonesia, but weak in Chile and Peru. On the other hand, participation was strong in Peru but relatively weak in Chile and Indonesia. The author suggested that the presence of these conditions is context dependent; they vary from country to country and from innovation to innovation. The importance and presence of these conditions were further confirmed in later studies (Hubbard and Ottoson, 1997; Murphy, 1998).
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Summary

Rogers (2003) originally hypothesized and confirmed the relationship between the five perceived characteristics of innovations and innovation adoption. Later studies, some of which have been reviewed here, have shown that perceived characteristics of innovations are also important determinants of innovation implementation. For the field of instructional technology, now commonly referred to as instructional design and technology (IDT), Surry and Brennan (1998), and Surry et al. (2002) recommended studies that focus on determining factors important in implementation of innovations. They observed that such studies have more value than adoption studies and should be the major goal of diffusion research in the IDT field. However, scholars have long bemoaned the general paucity of innovation implementation research based on diffusion of innovations theory (Klein et al., 1996; Surry et al., 1998; Rogers, 1983).

This review has shown that studies that draw explicitly from Rogers’ diffusion of innovations theory, especially on the main attributes of innovations as implementation predictor or explanatory variables, are seemingly rare. Those that closely attempted to do so were either done in corporate or non-educational settings (Goldman, 1994; Kaluzny et al., 1973), and their findings may not generalize across settings. In the same vein, a number of studies on perceived characteristics of innovations as factors in innovation implementation such as those by Dass (2001), Ely (1990, 1999a, 199b), Goldman (1994), Hughes et al. (1980), and Morris (1985) have found inconsistent and conflicting findings making it impossible to draw meaningful conclusions. For the most part, these findings lend partial support to the availability and importance of Rogers’ main innovation attributes as factors in the diffusion of innovations. Despite these inconsistencies, a meta-analysis study involving 75 studies by Tornatzky et
al.(1982) revealed that attributes of compatibility, relative advantage, and complexity were the most consistent determinants of innovation adoption-implementation.

Tornatzky et al. (1982) highlighted methodological flaws with most quantitative studies on implementation that render their results inconsistent and inconclusive. One of the common problems was the operationalization of many attributes far beyond those specified by Rogers (1983, 1995, 2003). There is need for studies that would draw explicitly from Rogers’ main attributes and investigate their predictive or explanatory value on various innovation implementations in order to permit meaningfully comparisons of findings across contexts. In addition, many innovation implementation studies are case studies utilizing varying methodological approaches and end up identifying varying sources of implementation success or failure. Klein et al. (1996) clearly explicated the difficulties associated with such studies:

Because each implementation case study highlights a different subset of one or more implementation policies and practices, the determinants of implementation effectiveness may appear to be a blur, a hodge-podge lacking organization and parsimony. If multiple authors, studying multiple organizations, identify differing sources of implementation failure and success, what overarching conclusion is a reader to reach? The implementation literature offers, unfortunately, little guidance. (p. 1059)

Rogers (1995) observed that, “one of the possible problems with measuring the five attributes of innovations is that they may not in all cases be the five most important perceived characteristics for a particular set of respondents” (p.209). This implies that the perceived characteristics of innovations are context-dependent. Consistent with Rogers’ (1995) observation that the perceived attributes of innovation are context-dependent, Ely also found that the eight conditions that facilitate innovation implementation were also context-dependent.
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Those that were available and strongly influenced innovation implementation in one context were not present in another change effort or if present did not influence innovation implementation equally strongly. Therefore, for the study of TALULAR innovation implementation, the perceived characteristics relevant to this innovation in a different context need to be investigated. In fact, Rogers (1995) suggested conducting a preliminary measure for each innovation to identify the most relevant and important perceptions and using them as determinants of the rate of adoption.

Status of education in Malawi

Introduction

Education is essential for nation building, good citizenship, economic prosperity, and poverty alleviation (World Bank, 1995). Improved educational quality, therefore, is a pre-requisite for Sub-Saharan nations to realize the educational benefits at both national and domestic levels. Wandiga (1994) provided good background information to the origin of education in Africa that traces it back to the missionaries who initially provided education to a few natives who could assist in spreading the gospel. The main goal of education was, therefore, to enable people to read the Bible and to train a few to be deacons and priests who could help spread Christianity. It was due to this status that Eisemon and Schwille (1991) observed that education was meant for the elite and practical training was for the masses during colonial administration in African States.

During the move toward independence in 1960s, most African nations viewed formal education as a means for national development (Jenkins, 1989; Mutangadura & Lamb, 2003; Winter, 1984) and social mobility (Wandiga, 1994). Using the same educational curricula, many African nations began to expand their education and opened up access to the masses. The
expansion of education and adoption and commitment to universal primary education (UPF) policy saw an unprecedented increase in the student enrollments (Jenkins, 1989; Winter, 1984), and the literacy rate in the Sub-Saharan region rose from 9% in 1960 to 42% around early 1980s (World Bank, 1988, cited in Jenkins, 1989). Educational expansion has been a blessing in disguise for many African nations. Some consequences of educational expansion and the resulting explosion of enrollments numbers augmented with economic decline in most African states especially the Sub-Saharan region, have been a decline in the quality of education and rising levels of unemployment among school leavers (Asagwara, 1997; Csapo, 1983; Jenkins, 1989; Winter, 1984). The decline in quality of education is manifested by a number of factors some of which are: low student achievement, shortage of well-qualified teaching force, shortage of teaching and learning materials, high teacher-pupil ratio and large class sizes, and high dropout and repeating rates. These challenges are shared by most African countries South of the Sahara, and Malawi is one of them.

In the sections that follow, the status of education in Malawi is discussed, and problematic areas characterizing Malawi’s education system common in most education systems in Sub-Saharan states that have led to the erosion of educational quality are highlighted. The other sections look at science education in general, science education in Africa, and science education in Malawi. The last section is a discussion of the TALULAR instructional innovation.

An overview of the status of education in Malawi

Malawi was one of the countries in Africa, South of the Sahara, which was once under the British colonial rule for about 73 years and got her independence in 1964. It is among the world nations classified by the United Nations as the least developed country [LDC] (Postlethwaite, 1998; The Ministry of Education [MoE] & The Malawi National Commission for
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UNESCO [MNC-UNESCO], 2004), and the World Bank classified it as one of the highly indebted nations (MoE et al., 2004). With a total population of around 13 million, about 60% of the population lives below the World Bank poverty line criterion equivalent to per capita yearly income of US $40 (MoE et al., 2004). The average literacy rate is estimated at 63.9%, and in terms of literacy rates by gender, 75% of male and 52% of female population are literate (National Statistical Office, 2006). The average life expectancy in Malawi is about 35 years (Glasson, Frykholm, Mhango, & Phiri, 2006).

Malawi was one of the first sub-Saharan African countries to adopt a Free Primary Education (FPE) policy in 1994 soon after the Jomtien World Conference on Education for All (EFA) in 1990. The new FPE policy opened doors of primary schools to millions of school-age children who were out of school (Government of Malawi, 2002; Ministry of Education Sports and Culture [MoESC], 2001). As a result of this policy, there was a dramatic rise in enrollment numbers in the primary schools (Lungu, 2005; MoESC, 2001). For instance, the enrollment swelled from 1.9 million in the year 1994 to 2.9 million in 1995 representing a percentage increase of about 66% after one school calendar year (Government of Malawi, 2002). The resulting expansion of the primary sub-sector exerted unprecedented pressure on the secondary school sub-sector. The Malawi government responded to the situation by building additional but insufficient number of new secondary schools, and converted what used to be called Malawi Distance Education Centers (DECs) into Community Day Secondary Schools [CDSS] (Lungu, 2005; MoESC, 2001), and recruited 18,000 untrained teachers the majority of whom were unqualified (Kadzamira & Rose, 2003). Conditions of schooling were already not very conducive to effective teaching and learning before the introduction of FPE (Edwards, 2005). Edwards (2005) further observed that classrooms had insufficient desks, very large classes, high
teacher and student attrition, and high repetition rates. However, before 1994, qualified and
tained primary and secondary school teachers out-numbered those that who were not (Tudor-
Craig, Tweedie, Cottingham, Carim, & Rodriguez, 2002). The implementation of FPE, however,
exacerbated the already poor situation leading to a further deterioration the quality of education.
Since the introduction of the Free Primary Education, both primary and secondary schools in
Malawi have been characterized by lack of basic teaching and learning resources, inadequate
qualified teaching force, high teacher to student ratios, poor student achievement as evidenced by
decreasing pass-rates on national examinations, high attrition and repetition rates, (Chimombo,
2005; Director-Education, 2005; Kadzamira & Rose, 2003; Lungu, 2005; MoESC, 2001;
Nsapato, 2005).

While there is no agreement regarding the definition of quality, there seems to be
consensus among researchers that the following are some of the key determinants or measures of
the quality of education or schooling: (a) students’ performance or achievement (Braun &
Kanjee, 2006; Fuller & Heyneman, 1989; Lee & Barro, 2001; Mehrotra, 1998), (b) teaching and
learning materials (Asagwara, 1997; Braun & Kanjee, 2006; Dorsey, 1990; Fuller, 1987; Fuller
& Heyneman, 1989; Postlethwaite, 1998), (c) quality of teachers or teacher education and
training (Asagwara, 1997; Braun & Kanjee, 2006; Dorsey, 1990; Fuller, 1987; Fuller &
Heyneman, 1989; Postlethwaite, 1998), (d) frequency of homework (Fuller, 1987; Postlethwaite,
1998), (e) curricula content (Asagwara, 1997; Braun & Kanjee, 2006), (f) teacher-pupil ratio
(Asagwara, 1997; Lee & Barro, 2001; Mehrotra, 1998; Postlethwaite, 1998), (g) repetition and
drop-out rates (Lee & Barro, 2001; Mehrotra, 1998; Postlethwaite, 1998), (h) class size (Braun &
Kanjee, 2006; Fuller, 1987; Postlethwaite, 1998), and (i) family background of students (Lee &
Barro, 2001).
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Fuller (1987) reviewed 60 multivariate studies conducted in the Third World and showed that some factors outlined above have a significant influence on students performance than others, particularly in developing countries. He found out that textbooks and instructional materials, years of tertiary and teacher training, length of instructional programs, frequency of homework, teacher’s time spent on class preparation, and school library activities were educational quality indicators consistently found to be the most effective in boosting student achievement in the Third World. On the other hand, class size, science laboratories, teacher salaries, and repetition of grades have been found to be less effective factors in influencing student achievement.

While it is impossible to discuss all aspects of Malawi’s education within the constraints of this paper, the discussion on the status of education in Malawi will focus on educational quality indicators as defined by the ministry of education in Malawi (MoESC, 2001), and specifically on challenges related student performance, teacher qualifications, resources for teaching and learning, teacher-pupil ratio, class sizes, attrition rates, and repetition rates. However, issues related to educational access, efficiency and equity will also be mentioned or implied in the process.

Student performance

Fuller (1987) reiterated that in defining educational quality it is essential, first and foremost, to look at student achievement before considering factors such as instructional materials and teaching practices that most significantly impact achievement. Low student pass rates from standardized national examinations is a common feature to many least developing countries most of which are in Africa (Winter, 1984). Accordingly, Braun et al. (2006) contended that achievement levels in most developing countries are low compared to both their
own internal standards and those established by developed countries. For instance, Hartshorne (1992, cited in Baine and Mwamwenda, 1994) observed that education in Southern Africa was characterized by high failure rates among black students on matriculation exams. Baine and Mwamwenda (1994) indicated that failure rates in Northern Transvaal and Johannesburg ranged from 44% to 73%.

Like most African states, south of the Sahara, Malawi’s education is marred with low student achievement or performance. This is evidenced by low student pass-rates in rigorous national examinations, which serve as gate-keeping means for students to advance to the next level (Davison & Kanyuka, 1992). Primary School Leaving Certificate (PSLC) examination, Junior Certificate Examinations (JCE), and Malawi School Certificate Education (MSCE) examinations are the exit exams at the end of primary school, junior secondary school, and senior secondary school education, respectively. The recent 2007 MSCE examination results indicated that out of the 86,652 candidates who sat for the exams, only 29,403 passed, representing a pass rate of 33.93% (Nation Newspaper, 2008). In 2006, the MSCE pass rate was 38.6% (Ndaferankhande, 2007). While it should be acknowledged there has been a slight and steady improvement in pass-rates since 2001, the pass-rates are still way too low. Over a period of 13 years, from 1993 to 2006, the average pass-rate has been hanging around 35%, meaning that only about a third of the students do well in the MSCE examinations each year. The high failure rate could be attributed to a number of factors, some of which are: poor quality of teachers, shortage of teaching materials, and the nature of examinations (Yadidi, 2006). Yadidi (2006) pointed out that often times the exams cover only a section of the entire curricula and does not reflect the national goals of education. According to the chief executive director of MANEB, the failure rates are due to failure by some teachers to adequately cover the syllabuses,
and the shortage of specialized teachers in Mathematics and science subjects (Ndaferankhande, 2007). Compared to pass-rates at MSCE, the pass-rates at primary (PSLC) and junior secondary (JCE) levels are quite higher despite the fact that all schools share similar characteristics in terms of quality of school resources. For instance, in 2007 the pass rates for PSLC and JCE were 93% ($N = 161,567$) and 56% ($N = 97,178$), respectively (Kandiero, 2007). In 2008, the pass rates for JCE and PSLC exams were 53.4% and 75%, respectively (Mtawanga, 2009).

Low student pass rates are also as a result of the nature of examinations and assessment systems in most African nations that were inherited from their colonial masters. There is great emphasis on examinations, which are used to sort out students and select those who would advance into the next grade level or are used as criteria for admission of a few bright students into secondary or tertiary education where spaces are limited (Moracco & Moracco, 1980; Olson, 1972). The high failure rates, therefore, could partly be attributed to the nature of such exams and assessment procedures (which are largely summative) as opposed to a lack of general ability of learners themselves. The emphasis on passing terminal examinations in the context of unqualified or untrained teachers has led teachers to resort to non-participatory approaches to instruction in order to complete their syllabi, and learners have tended to rote memorize content rather than engaging in deep processing and higher order learning (Baine & Mwamwenda, 1994). On the other hand, one may argue that MANEB, a body that is responsible for preparing and administering national examinations, may not be adequately taking into account the problems prevalent in Malawian schools. Among other things, a good assessment tool should take into consideration contextual factors that prevail in the learning environment. Some students feel unprepared for these examinations and many are disqualified as a result of cheating. For the 2007 national examinations, 66 JCE candidates, and 216 PSLC candidates were disqualified for
cheating. There are many factors cited in literature that are related to poor student performance and only a few are discussed in subsequent sections.

*Shortage of well-trained and qualified teachers*

Many African nations face a critical shortage of well trained and qualified teachers (Baine & Mwamwenda, 1994; Dorsey, 1990; Jenkins, 1989; Postlethwaite, 1998). After attaining independence, African states adopted universal and free primary education (UPE) policy, a recommendation made at the Addis Ababa Conference in 1961 (Winter, 1984). Winter pointed out that this stemmed from the belief by Africa states that access to education was not only a human right but also a means for developing an educated populace whose knowledge and skills would be important for effective participation in national development. The demand for teachers due to increased rate of enrollments greatly out-paced the rate at which teachers were produced and supplied (Lewin, 2002; Mulkeen, Chapman, Dejaeghere, Leu, & Bryner, 2005). The solution was to employ unqualified and untrained or under trained teachers to teach in both primary and secondary schools. Unqualified teachers have contributed to the low student achievement in the developing countries.

After Malawi adopted the FPE policy in 1994, enrollments at both primary and eventually at secondary school level swelled, and one of the government’s responses to the unprecedented increase in enrollment was to recruit unqualified or untrained teachers (Kadzamira et al., 2003, MoES&C, 2001). In a national needs assessment carried out in 2003 that aided in the establishment of distance education for secondary school teachers in Malawi, Zozie, et al.(2004) found that 44% of secondary school teachers were unqualified. Data from the ministry of education showed the following proportions of unqualified teachers at each level of education: 63% in conventional secondary schools (CSS), 99% in community day secondary
schools (CDSSs), and 51% in primary school, 75% in teacher training colleges (TTCs), and 65% in technical and vocational institutions (T&VI), 80% at university level, that is, those without a PhD (MoESC, 2001). Evidently, the shortage of a qualified teaching force is critical at all levels of education in Malawi. More disturbing, however, is the fact that about half of the primary school teachers are not qualified. The quality of teaching force at primary level is very critical because primary education is a foundation on which the entire education system is built, and its level of quality will, to a larger extent, influence the quality of the overall education system (Asagwara, 1997).

According to the government of Malawi, basic education, which is mostly primary education, is terminal for most Malawians and its main goals are: (a) to equip students with basic knowledge and skills to so that they can function as competent and productive citizens, and (b) as a main vehicle for poverty reduction (MoESC, 2001). It is doubtful, looking at the quality of staffing and the implications it has on educational quality, if the government is really committed to reaching these goals. Similarly, the government’s aim regarding secondary education is to provide the basis for enabling school leavers develop capacity for useful informal as well as formal employment, while at the same time serving as a preparation for further education (MoESC, 2001). Unfortunately, as was in the colonial era, secondary education in Malawi is still very elitist only serving a few group of the population. At the moment, only about 18% of the primary graduates have access to secondary education (MoESC, 2001) and this proportion will increase with time as primary school enrollment is continuously increasing. In addition, tertiary education caters for even a fewer percentage of secondary school graduates. Therefore, the dominance of unqualified and untrained teachers in the education system is self-defeating and counterproductive to the realization of the potential benefits of education.
The government, through the ministry of education, should be commended for the initiatives it has undertaken aimed at improving the quality and quantity of trained teachers at both primary and secondary levels. After the launching of FPE in 1994, Mzuzu University, Malawi’s second public university was established in 1997. The university has expanded rapidly and has significantly contributed to alleviating the problem of shortage of qualified teachers by preparing both pre-service and in-service secondary school teachers. The ministry of education has also embarked on projects in training thousands of unqualified teachers by employing innovative ways of teacher training using mixed mode. One such initiative was the in-service training of unqualified primary school teachers in a program called MIITEP (Malawi In-service Integrated Teacher Education Program). The program’s goal was to train as quickly as possible, the 18,000 unqualified temporary teachers holding an MSCE or JCE qualification, who were recruited following the launch of the FPE policy in 1994 (Lewin, 2002). The program utilized mixed mode (a combination of residential or face-to-face learning and correspondence learning) distance education in which a larger part was correspondence learning (Kunje & Chimombo, 1999). This program emerged due to the realization that traditional ways of teacher preparation were not only inadequate to satisfy the dramatic increase in the demand for qualified teachers but were also financially unsustainable (Lewin, 2002). The MIITEP program was cost-effective compared to traditional ways of teacher preparation (Lewin, 2002), and managed to mass-produce teachers by recruiting multiple cohorts each year and by 2005, 23,419 in-service teachers were trained and qualified. The problems with the program included the following: (a) tutors were unqualified and ill-prepared to teach at a distance and advocated passive approaches to teaching, (b) many students had weak academic backgrounds and struggled to get through the program, and (c) tutor supervision of student internships raised the cost of the program (Kunje,
2002). Others argued that the MIITEP program failed to produce quality teachers as teachers were deficient in content (Mosha, 2002).

A similar in-service program that targeted serving secondary school teachers was the SSTEP (Secondary School Teacher Education project). The program was initially funded by the Canadian International Development Agency (CIDA) and coordinated by Domasi College of Education and two other Canadian Universities (SSTEP Malawi, 2002). This program targeted unqualified Community Day Secondary Schools who were awarded a diploma in education after 3 years of correspondence learning (10 months of correspondence learning every year) combined with short durations of campus-based face-to-face instruction (G.H. Zembeni, personal communication, February 14, 2007).

Unlike MIITEP, SSTEP has been institutionalized by Domasi and the government completely funded the program in 2006 (SSTEP Malawi, 2002). While such efforts deserve credit, the supply of primary and secondary school teachers remains very low and fails to meet the demand for qualified teachers as traditional teacher preparation institutions only enroll a handful of students who later on take teaching positions.

*High teacher to pupil ratios and large class sizes*

Sub-Saharan African states re-affirmed their commitment to achieving UPE by 2015 at the World Education Forum held in Dakar in 2000 (World Education Forum, 2000). Access to basic education by the masses has been isolated as the most essential component in improving the living standards of the poor (Bennel & Furlong, 1998; World Bank, 1995). While these efforts should be applauded, most African states are ill-prepared for the consequences of education expansion and have witnessed a decline in the quality of education. Many least developed countries (LDCs) in Africa face problems of very large class sizes and high teacher to
student ratios (Baine & Mwamwenda, 1994; Postlethwaite, 1998). For instance, class sizes of 40-70, and teacher-student ratios of more than 1:40 are not uncommon in LDCs. There are also some extreme cases of 73 to 118 students per class and teacher-student ratios of up to 1: 80 as in Equatorial Guinea (Postlethwaite, 1998).

In Malawi, teacher to pupil ratios at both primary and secondary education are very high. The problem is much worse at primary level. For instance, the reported teacher to pupil ratio at primary level is 1: 118 when only qualified teachers are accounted for, and 1:66 if both qualified and unqualified teachers are included (MoE et al., 2004). According to Chimombo (2005), extreme cases have been found in which teacher to pupil ratios of 1: 143 exist in primary schools. At secondary school sub-sector, teacher to pupil ratio is 1:40 (MoESC, 2001), which is much less than those reported at primary school sub-sector.

Studies on the relationship between class size and student achievement have shown that smaller class sizes enhance students’ achievement (Fuller, 1987; Glass & Smith, 1979; Lee & Barro, 2001). This is expected because smaller classes tend to increase the frequency of teacher-student interaction (Lee & Barro, 2001), while in large classes teachers tend to employ non-participatory instructional approaches. According to Psacharopoulos and Woodhall (1985, cited in Lee & Barro, 2001) learning in large classes is dominated by rote memorization than problem-solving. Conceptually, teachers in large classes are also unlikely to give frequent student homework. Fuller (1987) found that more frequent student homework is positively related to achievement. It is important to note that it is practically impossible to reduce class sizes to sizes of about 20 as this will demand more classrooms and teachers, which are already in short supply. This would alternatively lead to double-shifting, which in turn would reduce
instructional time. Postlethwaite (1998) found that the reduction in instructional time is negatively related to student achievement.

While problems of high teacher to pupil ratios and large classes prevalent in Malawi’s schools could largely be attributed to inadequate number of qualified teachers, other factors such as the shortage of physical resources (classrooms and desks, and teacher houses) have also contributed to such problems. These school-related factors are detrimental to efforts geared to improving the quality of education and bear testimony to the fact that education expansion, if it is going to be successfully implemented, should be done both systematically and holistically.

High student attrition and repetition rates

High drop-out rates and repetition rates have been long-standing problems in educational systems in developing countries (Fredriksen, 1983; Mehrotra, 1998; Sunal, 1995; Winter, 1984; World Education Forum, 2000). For instance, the drop-out rate at primary school level in Sub-Saharan Africa by 1998 was estimated at 66% (Mehrotra, 1998), and the survival rate (number of students who successfully complete all primary grades as a percentage of those who entered school at grade 1) was between 40-70% in the least developed countries (Postlethwaite, 1998).

In general, drop-outs in most Sub-Saharan countries are related to the following factors: (a) increased costs of education for parents who are living in poverty, or political instability and wars (World Education Forum, 2000), (b) learning problems related to language of instruction, which in many cases is not spoken at home and, besides poverty and illiteracy of parents (Mehrotra, 1998), (c) failure to learn expected content due to poorly trained or unqualified teachers who have limited instructional strategies (Sunal, 1995), (d) high teacher to student ratios, and teachers’ lack of innovative teaching strategies (Sunal, 1995), (e) low perceived benefits of schooling by parents and children (Mehrotra, 1998), and (f) conflict between cultural
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expectations and continued schooling. For instance, in Sub-Saharan Africa, the fundamental role of girls in society is to transmit cultural norms to children and continued schooling is perceived to be an infringement to marriage (Sunal, 1995).

There is empirical evidence that students taught in their mother tongue learn to read both their mother tongue and foreign language more quickly than when taught in a second or foreign language (Mehrotra, 1998). Additionally, students who are taught in their mother tongue acquire academic learning skills more quickly than those taught in a second language (McGinn & Borden, 1994). Based on these findings, some countries in Africa, like Malawi, have adopted policies which encourage use of mother language in teaching, especially in the early grades of primary education. However, a big challenge to such policies is the choice of one teaching language in countries that have multiple mother tongue languages. In addition, teacher deployment becomes problematic as deploying teachers based on mother tongue language would have very adverse political implications.

Malawi is one of the Sub-Saharan countries that reports high student attrition and repetition rates especially at primary school level. In 2000, the average drop-out rate at primary education in all standards was 18.4% with more cases of girls (9.8%) dropping than boys (8.6%), and the average repetition rate by 2000 was at 15.5% for girls and 15.7% for boys with no observed significant differences between boys and girls (Maluwa-Banda, 2004). However, the drop-out rates are higher for both boys and girls in lower classes and in the final primary grade (Maluwa-Banda, 2004). Many students who enter primary schooling do not complete their primary education. For instance, according to the MoESC (2001), the completion rate at primary school is 40% signaling very serious problems of internal efficiency in the primary school system.
There seems to be a paucity of data on drop-out and repetition rates at secondary school level. However, it is envisaged that the rates could be much lower than those reported at primary school level, and the drop-outs could mainly be due to student failure at JCE and MSCE examinations. According to Maluwa-Banda (2004), transition rates from form 1 (or grade 9) to form 2 (or grade 10), and from form 3 to form 4 are nearly 100%. Many factors, which contribute to drop-out rates and repetition rates in Malawi, have been cited. Some of them are: (1) social-cultural factors: (a) direct costs of schooling due to poverty, (b) early pregnancies, (c) unfavorable parental attitudes to schooling, and poor or lack of academic aspirations for children (Maluwa-Banda, 2004), (d) early marriages, and (e) initiation practices, which draw pupils away from school (Chimombo, 2005; Maluwa-Banda, 2004). (2) school factors include: (a) long distances to school, (b) poor academic performance, and (c) shortage of school resources (Davison & Kanyuka, 1992; Kadzamira & Chibwana, 1999).

From the preceding discussion, it is not surprising that despite the implementation of UPE, many African countries, including Malawi, have not achieved a 100% gross enrollment ratio (GER). 100% GER is an indicator of achieving UPE and it happens when the number of children enrolled in school-and remain enrolled for a full duration of the cycle- is equal to the number of children of primary school age (Fredriksen, 1983). Repetition rates may also be a function of poor academic performance of students in examinations, which are used as yard sticks for determining if a student is ready to proceed to the next level or not. Unless something is done to improve the quantity and quality of school resources, the trend in drop-out rates and repetition-rates will continue to haunt Malawi’s education sector.
Shortage of teaching and learning materials

At the 1990 Jomtien World Conference on Education for All (EFA) in Thailand, developing nations committed themselves to providing universal primary education (UPE) to around 129 million 6-11 year olds who were out of school (Mehrotra, 1998). As a follow up on the Jomtien conference, a 1995 survey sponsored by UNESCO to gather information on the conditions of primary schools in 14 of the 48 least developed countries (LDCs), most of which are in Africa, revealed, among other things, that the shortage of teaching and learning materials in these countries was appalling (Postlethwaite, 1998). Others have also reported the same educational problem prevalent in most African nations at both primary and secondary levels (Asagwara, 1997; Braun & Kanjee, 2006; Dorsey, 1990; Mulkeen, Chapman, Dejaeghere, Leu, & Bryner, 2005).

Critical shortage and sometimes lack of teaching and learning materials is a widespread problem in public schools across Malawi (Chilora et al., 2003; Kadzamira & Rose, 2003; Lungu, 2005; MoESC, 2001; Nsapato, 2005). The availability of adequate teaching and learning materials has been consistently found to have a strong and positive influence on students’ achievement in developing countries than in developed countries (Postlethwaite, 1998, Fuller, 1987, Lee and Barro, 2001). They raise the quality of learning activities thereby increasing student achievement (Fuller, 1987). A study by Fuller and Henryneman (1989) found that teaching and learning resources had a greater influence on student achievement in developing countries than in developed ones. According to the authors, this scenario was due the very low baseline level of resource quality and quantity in the developing countries. That is, many schools in the developing countries lack basic school resources as compared to their western counterparts. The shortage of teaching and learning materials is mainly due to low government expenditures on
teaching and learning materials (Komenan, 1987). In addition, most African countries have school curricula that closely resemble those found in the developed nations (Talisayon, 1984; Wandiga, 1994). These curricula demand very expensive commercially-produced materials and equipment, which most poor nations can not afford.

The prevalent and exceedingly low pass rates in national examinations at senior secondary school level are obviously related to the shortage and lack of teaching and learning resources. Like other countries in Sub-Saharan Africa, the shortage of teaching and learning materials in Malawi is mainly due to government low education financing due to poor economic growth, rapid population growth, and the rising demand for schooling. In addition, the nature of curricula, which to a large extent still resemble those of the British colonial administration, demand commercially-produced materials or equipment that can not be sustained under the prevalent economic situation. While curricula reforms have been undertaken, they have not managed to comprehensively address this challenge.

It is worth pointing out that the problem of shortage of teaching and learning resources is more serious in community day secondary schools (CDSSs) than in many conventional secondary schools (CSSs). Before the introduction of FPE in 1994, CDSSs were distance education centers (DECs), which served students that were not selected to CSSs. Such centers neither had laboratories or adequate resources nor did they have adequate qualified teachers, and mainly served as centers where students would order and receive print-based distance education materials. After the introduction of FPE in 1994, all DECs were converted to public secondary schools to accommodate the unprecedented increased number of primary school graduates who were looking for secondary education. While the conversion of CDSSs was necessary to expand the capacity of secondary education system to many Malawian children, the process was done
without a corresponding increase in the supply of the educational resources necessary to ensure quality of teaching and learning. A comparison of performance in national examinations at MSCE level between CSSs and CDSSs in 1997 revealed that CSSs achieved a significantly higher pass rate of 36% while CDSSs achieved only 8% pass rate. The problem of quality education in CDSSs is exacerbated by a significantly higher proportion of unqualified and untrained teachers when compared to CSSs.

While urging developing countries to increase public expenditure on education in order to increase resources for education seems to be a plausible policy recommendation (Mutangadura & Lamb, 2003), it is worth noting that over financing education would paralyze the provision of other critical public services (Fredriksen, 1983). For instance, Malawi, like other Sub-Saharan African nations, is also spending huge amounts of her financial resources serving high foreign debts (Mutangadura & Lamb, 2003; Stephens, 1991) at the same time fighting high levels of poverty and HIV/AIDS. The shortage of basic teaching and learning resources and qualified and well-trained teachers remain the top two problems that the government of Malawi must deal with in order to make significantly impact on student achievement and improve the overall quality of education.

Summary

From a review of literature, it is undisputable that conditions in primary and secondary education in Malawi, in particular, and in most African states in the Sub-Saharan region, in general, are not conducive to learning. Key educational problems which Malawi and other Africa states had to deal with since independence that continue to haunt the education sector include the following: (a) lack of adequately qualified and trained teachers, (b) inadequate supplies of teaching and learning resources, (c) expanding class sizes and teacher ratios due to increasing
enrollments, (d) high drop-out and repetition rates, and (e) lack of adequate classrooms and lab facilities (Gama, 2000). The expansion of primary education after independence brought forth formidable challenges not only in the primary education system but also in the post-primary education systems. It was easy for a number of African nations to implement UPE and FPE policies in an effort towards realizing EFA than to adequately finance and continuously provide educational resources needed for the sustainability of such programs and for quality control.

Expansion of primary education in terms of access without the corresponding expansion in post-primary education, and the provision of adequate school resources raises serious doubts about the extent to which many African nations are really committed to fighting illiteracy, poverty, and scarce human resource. Education as an investment requires quality inputs in order to realize quality products or outcomes. As stated by (Glewwe, 1996), “A poor quality education may well be a poor investment” (p. 268). There is no doubt that the increased access to education through the provision of FPE is being pursued at the cost of the quality of education (Chimombo, 2005).

The fundamental problem for most African countries has been growing conflict between ever-rising enrollments and falling resources (Fuller et al., 1989) making these nations incapable of adequately financing education. This situation has led to the erosion of educational quality. It is unlikely, however, that many African countries will experience economic boom in a short term, and the provision of a quality education depends on the identification of educational innovations that will raise the quality of schooling. Innovative ways are required in areas of teacher recruitment and preparation, and teaching and learning resources from the immediate environment that could serve the same purpose as those that are produced commercially. Therefore, innovations that are geared at solving the shortage of teaching and learning resources such as TALULAR, which countries like Malawi have embarked on, have a great potential in
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revolutionizing education in low-income nations and contributing to improved quality of education. The government is, therefore, called upon to mobilize its resources in support of the innovation diffusion process.

The government, however, should be commended for the many initiatives it has carried out in the education sector in an attempt to improve the provision of both educational quality and access. First, the expansion of primary education through the introduction of FPE has enabled disadvantaged Malawian children to access affordable education. Second, credit should be given for the curricula reforms that have taken place at primary and secondary sub-sectors aimed at making education more relevant to the local needs and context. However, more still remains to be done to make the curricula more responsive and adaptive to the Malawian context. Third, the government has made strides in training unqualified serving teachers through cost-effective programs that utilize a combination of correspondence and face-to-face mode. While such efforts have mainly targeted serving teachers, there is need to extend such initiatives to cater for pre-service teachers as well. Fourth, the expansion of education has afforded more Malawian children access to primary, secondary and tertiary education. However, the growing enrollments at primary education far outpaces the expansion of post-primary and post-secondary education and every year the education systems fails to absorb hundreds of thousands of potential candidates. For instance, out of the 150,670 candidates who passed the 2007 PSLC examinations only 32% (or 48,604 students) were selected to various public secondary schools in Malawi (Kandiero, 2007). Sadly, the secondary education sector could not find space for the remaining 68% of capable primary school leavers. This scenario testifies to the fact that the government has not done enough in improving educational access at post-primary levels.
General overview of science education

In this section, a general overview of science education is provided. The discussion of science education, in general, will be followed by a discussion of science education in African states, especially south of the Sahara. This will set the context for discussing science education in Malawi.

Science, in a simplistic view, is a way in which we make sense of our world in which we live (Salisbury, 1985). Throughout history, human progress has, to a larger extent, relied on the understanding of the world around us and the application of such knowledge to solve human perceived problems (Jemison, 2003). The discussion of the state of education in Africa revealed that the situation in most African schools is not conducive to learning. Major challenges to education included poor student achievement and a declining quality of education mainly due to: inadequate number of quality teaching force, shortage of learning and teaching materials, family backgrounds, frequency of homework and instructional time, large classes, and other problems related to educational access and equity.

According to Johnson (1962), the overarching goal of science education is to have citizens who are scientifically literate. In addition, he pointed out that science education in primary and secondary schools should enable some students to go beyond the basic literacy and prepare them for further studies. While there is much debate about what constitutes science literacy, “scientific literacy is broadly accepted as a term to describe the science-related knowledge, practices, and values that we hope students will acquire in school” (Brown, 2005, p. 1). A scientifically literate individual possesses some of the following characteristics: (a) has a broader scientific knowledge, (b) is curious and open minded about the phenomena happening within his or her environment, and tries to make objective observations and find explanations,
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and (c) is open-minded and interested to hear and learn about ideas and issues that are of interest to scientists even if they are perceived as alien to his or her society, and comes up with the best judgment about the quality and value of such ideas (Johnson, 1962). While Johnson contended that such a person may never create any scientific ideas, he or she is conversant with scientific principles in their broadest sense and his or her opinions and values are based on knowledge acquired through formal education.

Within this context, the following sections discuss challenges facing science education in Africa under the following three themes: (a) school-related factors, (b) cultural factors, and (c) curricula factors.

Science education in Africa

In this section, the status of science education in Sub-Saharan Africa will be discussed. The quality of science education is affected by almost similar challenges that are prevalent in most Sub-Saharan nations. Areas that pose formidable challenges to the teaching and learning of science will be discussed, and such areas can be broadly categorized as follows: (a) school-related factors, (b) cultural factors, and (c) curricula factors.

School-related factors

Soon after independence, many African nations began to realize that in absence of a quality science education, it was impossible to achieve economic development (OAU, 1981). In line with this realization, a lot of investment has been done aimed at improving science education by training science teachers, developing new science curricula, producing new science textbooks, and expanding classes and laboratories (Ogunniyi, 1995). Despite these efforts, there still exists challenges to the provision of a quality science education that are related to the following: (a) shortage of well trained and qualified science teachers, (b) inadequate teaching
and learning materials (Ogunniyi, 1995; Talisayon, 1984), (c) poor teaching methods (Ogunniyi, 1995), and (d) high student-teacher ratios (Talisayon, 1984).

Shortage of qualified science teachers. In developing countries where science education receives inadequate financing, the teacher is the most vital resource for science education in the classroom. However, if these teachers are unqualified, Salisbury (1985) argued that they will have difficulties to successfully teach science to students. Studies have shown that there is strong and positive relationship between the quality of teachers in terms of years of tertiary education and teacher training, and student achievement (Fuller, 1987). Unqualified teachers in developing countries have contributed to the low students’ achievement in science. First, they lack subject content knowledge, which is vital for effective teaching (Kalande, 2006), and second, they are deficient in pedagogical content knowledge as well as curricula knowledge. Darling-Hammond (1997) noted that teacher education is of great importance, and her follow-up study for the National Commission on Teaching and America’s Future (NCTAF) provided evidence that students accorded a lot of confidence in teachers who were well trained in both subject content and pedagogy.

Teachers in Africa who are not well prepared exhibit negative attitudes toward the science subjects if asked to teach them (Salisbury, 1985). Salisbury suggested that teachers’ attitudes could be improved if they could be taught ways to emphasize the relevance of science to everyday life experiences. By doing so, the problem of science education that has stood the test of time—the perception that science subjects are difficult, abstract, intriguing and many times irrelevant to the needs of learners (Kruckeberg, 2006)—could be minimized. For the same perceptions that students have in science, enrollments in science subjects beginning at secondary level are low, and the situation is very worrisome at university level (Muwanga-Zake, 2001).
This makes it very difficult for African countries to produce and supply an adequate number of secondary school science teachers.

*Shortage of teaching and learning resources.* One of the common educational problems facing schools in most African countries is the scarcity of basic teaching and learning materials and equipment for science (Talisayon, 1984). While this problem is mainly due to inadequate educational financing because of economic decline, it also has historical origins. During the colonial era, education was for the elite, and governments could afford the supply of resources prescribed by the curriculum. With the expansion of education, after independence, and resulting increased in student enrollments, African countries have found it hard to maintain educational curricula left behind by their colonial masters. Sciences education has suffered a great deal because of the reliance on expensive commercially produced materials and equipment called for in science curricula, which remain carbon copies of the ones that existed until the 1960s (Wandiga, 1994).

Science is best learned through scientific inquiry, which goes beyond the development of science process skills, namely: observation, inference, classification, prediction, measurement, questioning, interpretation, and data analysis (Lederman, 2003). Lederman further contended that scientific inquiry helps students develop scientific knowledge by combining these scientific processes with scientific knowledge, scientific reasoning, and critical thinking. Therefore, inquiry based-teaching approaches such as problem solving, discovery and guided discovery, and project-oriented learning are the most relevant for science education today (Deboer, 2002).

Although the problem of unqualified and well-trained science teachers could be resolved, the scarcity of teaching and learning resources poses a big challenge for African schools to cultivate in learners the much needed knowledge and skills through the implementation of inquiry-based
teaching approaches. Thus, science teaching will continue to be dominated by passive, teacher-centered approaches such as lecturing, and learning will reduce to rote memorization of scientific facts (Wandiga, 1994) to pass examinations, a situation that is detrimental to science learning. In this context, African countries are far from realizing the goals of science education or benefiting from the contribution of science and technology to the social-economic development of human civilizations.

*Over-crowded classrooms.* The problem of large classes, especially at primary level, negatively impacts the teaching of science. With large classes and heavy teaching load, teachers can hardly implement participatory approaches to science teaching. This situation becomes even more compounded by the scarcity of teaching and learning materials. In a two-year qualitative study that investigated Malawian teacher educators’ perspectives and dispositions towards teaching about ecological sustainability issues, Glasson et al. (2006) found that large classes was one of the biggest challenges for implementing inquiry-oriented approaches to primary science teaching.

*Cultural factors*

There is a reciprocal relationship between science and culture. While science may be influenced by societal or cultural values, such values in turn might also be shaped by science. This section discusses cultural-related factors that pose challenges to science education in African states. Such factors are not unique to Africa, and there is evidence, which suggests that these factors have significantly contributed to the problems related to science learning in some developing nations. Cultural factors discussed here related to language of instruction in science, cultural values, and African worldview or traditional world view,
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Language for teaching and learning science. Language presents the most formidable cultural barrier to learning science for most African students (Henderson & Wellington, 1998). As already pointed out in the preceding sections, science curricula in most African countries mimic those found in Europe and America, and science is mainly taught in foreign or second language, particularly English (Gray, 1999; Muwanga-Zake, 2001). Empirical findings indicate that the teaching of science in English, which is not a common spoken language, makes it difficult for students to construct meanings of scientific concepts and fail to relate such concepts and processes to their everyday experiences (Rollnick & Rutherford, 1996). Dlodlo (1999) pointed out that one of the arguments given in support of using English as an instructional language for science is that indigenous languages lack a rich scientific vocabulary essential for explaining scientific ideas. Dlodlo considered such arguments as legitimate, and urged African countries to strive towards developing an adequate and rich vocabulary if indigenous languages are successfully to be used for science teaching. Efforts are being made in some African countries like South Africa where scholars are developing a science vocabulary using indigenous Nguni language so that it could be used for Physics teaching (Dlodlo, 1999).

Traditional or African worldview. Worldview, according to Shumba (1999), “is the overall perspective from which one sees and interprets the world, i.e., a collection of beliefs about life and the universe held by an individual or group” (p.333). The worldviews students bring to class are the greatest source of misconceptions that are obstacles to conceptual understanding. Results of a study, which examined the nature of some selected traditional cosmological concepts among literate and illiterate Nigerians, showed that the subjects, regardless of their level of education, sex, age, religion, and tribe, held varied traditional and scientific notions of the universe (Oguniyi, 1987). Such worldviews include the following: (a)
that a rainbow signifies that a lion or a tiger is giving birth somewhere or an impending misfortune to society (Oguniyi, 1987), and (b) the belief that it is the sun, and not the earth, that is in motion. These notions about the universe are carried into the science classroom by students and present a big challenge for teachers, particularly those who are unqualified or untrained. Such a challenge in shaping students misconceptions was articulated by Duschl (1990) when he pointed out that, “the challenge for science teachers is how to design instructional strategies that will promote the evolution of students naive views into the more sophisticated scientists’ views” (p.12). Teachers are, therefore, called upon to first uncover such misconceptions and to use appropriate strategies to transform students’ misconceptions. Strategies that have a great potential in this transformation, such as the use of analogies and models that are familiar to students’ everyday experiences (Coll, France, & Taylor, 2005), and the use of other inquiry-based approaches that would create a cognitive conflict leading students to search for the best alternative explanation for scientific phenomena, are encouraged.

Cultural values. Students carry with them cultural traits into the science classroom, and sometimes these traits are in direct conflict with the methods of learning science. For instance, inquiry-based approaches to teaching science require students to take an active role in the learning process and are given the opportunity to question the views of the teacher as they construct meaning. According to Shumba (1999), such approaches conflict with most African cultural values in which children are taught to respect the knowledge and authority of the elders. In the process, students view the teacher and their textbooks as authoritarian sources of scientific knowledge in which they are expected to accept the information at face value and passively imbibe the so called scientific facts.
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Culture also impacts teachers on their choice of teaching methods. A study conducted in Zimbabwe, which sought to measure secondary science teachers’ level of commitment to traditional culture, and how such an orientation was related to science instructional beliefs, Shumba (1999) found that teachers orientation toward indigenous culture was positively related to preference for traditional non-inquiry instructional approaches and was negatively related to inquiry-based instructional practices to science. The study also found that teachers had authoritarian tendencies to teaching science as revealed by their ratings of students’ roles in instructional decisions.

*Science curricula*

Developing countries tend to emulate science curricula in developed countries, resulting into curricula that not only fail to be relevant to their socio-cultural contexts (Gray, 1999; Wandiga, 1994), but are also unaffordable given their economic status (Gray, 1999). Wandiga (1994) argued that such developments have hindered the development and realization of a high quality science education in most of African countries. Evidence of this scenario is found in South Africa, where curricula materials read very much like those found in Australia and New Zealand without much regard to contextual relevance and resource availability (Gray, 1999). There is need for African countries to emphasize topics in the science curricula that have a greater cultural and economic relevance outside the school so that primary and secondary school leavers-the majority of whom do not go to college-are adequately prepared to utilize such ideas for improving their rural livelihood and contributing to socio-economic development of their nations. Wandiga (1994) also expressed concern over the emphasis Africa educational systems put on examinations. He argued that by emphasizing passes at entry level examinations, science learning is dominated by memorization rather than problem-solving, theory is emphasized at the
expense of practice, and the entire curricula become unsuitable for most of the school leavers who are expected to use scientific ideas and skills to increase productivity in their communities.

Despite these challenges to science education in most African educational systems, there are positive developments that have taken place and deserve credit. For example, in Botswana strides have been made in transforming science curriculum to reflect the socio-cultural context of the nation (Oguniyi, 1986). Other curricula reforms across Africa countries are based on tenets such as science for all, scientific applications, relation between science and everyday life (Gray, 1999), and the popularization of science (Salisbury, 1985). In South Africa, as mentioned in earlier sections, experts are in the process of developing a meaningful and authentic scientific terminology in Nguni language that could potentially transform the teaching of science (Dlodlo, 1999). Countries like Malawi are beginning to implement innovative ways of teaching and learning using locally available resources as a solution to the scarce and expensive commercially produced materials (Chakwera et al., 2001; Chilora et al., 2003; MIE, 2004). There is a general understanding that locally available resources could effectively replace expensive laboratory equipment and still make science learning effective (Chilora et al., 2003; Gray, 1999; 2003; Lewin, 2000; Talisayon, 1984; Wankat & Oreovicz, 2001).

**Summary**

While African cultural practices, values, and traditional worldviews present obstacles to effective teaching and learning science, there are ways in which such values, practices, and ways of making sense of the world could facilitate the teaching and learning of science within the African context. The arguments in this paper should not be perceived to purport the replacement of an African culture with the western culture, and any efforts to do so would undoubtedly be unfruitful. Instead, it suggests that the teaching of science should integrate some aspects of the
African culture or traditional worldview that could make science learning more meaningful. The common threads that exist in both of these worldviews as shown by Oguniyi (1987) could be used to foster science teaching in African science classrooms. Boulding (1970) made an important contribution when he asserted that:

What we have to think of, therefore, is much more of a symbiosis between the scientific sub-culture and the other subcultures with which it is surrounded and with which it interacts, rather than any sort of conquest of the other cultures by a kind of universal church or a culture of science. (p.17)

For teachers to effectively utilize traditional worldviews in the teaching of science, teacher preparation programs have a responsibility to introduce such ideas to pre-service and in-service science teachers to map out strategies that would effectively utilize such beliefs for the advancement of science. In addition, the scarcity of teaching and learning resources, and the shortage of qualified teachers negatively affects the provision of quality science education to many African children. In order to provide rich science educational experiences, teachers are encouraged to be creative, self-assertive, and rise above the scarcity of resources to adopt and implement instructional innovations that call for the utilization of locally available resources.

The status of science education in Malawi

Some of the goals of science education in Malawi include: (a) to prepare students to be effective scientists and use the scientific method in investigating problems, and (b) to cultivate in learners scientific knowledge, skills and attitudes (MoESC, 2001). There appears to be a paucity of literature on science education in Malawi. The challenges facing education and science education in African countries have been highlighted in the preceding sections. The problems facing education and science education in Malawi are very similar to those already
discussed under education and science education in African countries. Given the conditions of schooling in Malawi, it can be envisaged that science education is more disadvantaged given the conditions necessary for the provision of a quality science education. In this section, problems existing in Malawian education system and how they have impacted science education will be highlighted. The discussion will focus on the following aspects: (a) quality of teachers, (b) teaching and learning resources, and (c) class sizes. Within these themes, the discussion will also focus on how such factors that have impacted students’ performance in science.

Quality of science teachers

Malawi lacks an adequate number of well-qualified and trained science teachers (Lungu, 2005). The demand for science teachers has risen to very high levels as a result of increasing enrollments numbers at primary school level and subsequently at secondary school level. A survey conducted in the Northern part of Malawi found that about 46% of secondary school science teachers were unqualified or under qualified (Lungu, 2004). Although this survey was done in one region out of the three regions, it provides useful information about the seriousness of the problem of science teacher shortage in Malawi. At secondary school level, science teaching is dominated by teacher-centered approaches that do not actively involve students in the learning process (Lungu, 2005). Lungu contended that such approaches encourage rote learning for the sake of passing exams. Passive teaching approaches are unlikely to cultivate in learners analytical, reasoning, and problem-solving skills that are most desired and are useful beyond the classroom setting. Such teaching practices are as a result of teachers’ lack of thorough content and pedagogical knowledge. In a study that sought to examine the teaching approaches used by primary school science teachers, Kalande (2006) found that teachers did not actively involve students in the learning process, and made use of monotonous teaching strategies. Research
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shows that actively involving students in the learning process, especially frequent practical work or hands-on and minds-on experiences, is positively related to student achievement (Stohr-Hunt, 1996).

These problems highlighted here contribute to the reported poor performance of students in science subjects in Malawi. For instance, the failure rate in physical science in the 1994 MSCE examinations was 27% compared to 8% in English (Mbano, 2003). Mbano also observed that most students absconded science exams and reported that in 1994, 24% of students did not show up to take the physical science exam.

The government of Malawi should, therefore, seriously consider financing teacher education programs that are aimed at improving teachers’ subject-content knowledge and pedagogy in order to improve the quality of science education and increase students’ motivation and achievement in science subjects.

*Resources for teaching science*

There is a critical shortage of teaching and learning resources for science teaching at both primary and secondary school levels (Director-Education Methods Advisory Services [DEMAS], 2005; Lungu, 2005; Nsapato, 2005). This problem, besides the shortage of qualified and well-trained teachers, is more acute in most CDSSs than in CSSs (Chakwera, 2005; Lungu, 2005). When DECs were elevated to CDSSs, and enrollment numbers swelled, there was no corresponding increase in the supply of a qualified and well-trained teaching force or teaching and learning resources. Today, most schools (CDSSs and CSSs), lack or have inadequate basic resources for teaching science. The problem of shortage of science resources has roots in the nature of science curricula, which more closely resemble the Nuffield British Science curricula and demands expensive commercially-produced materials, and is due to the government’s
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inability to adequately finance education as a result of economic decline. Because of lack of resources for teaching science, teachers tend to rely heavily on traditional and passive approaches to teaching science (Lungu, 2005). This is counterproductive as science requires active learner participation (hands-on and minds-on inquiry) in order to facilitate the development of higher-order reasoning skills, such as problem solving skills, observational skills, analytical thinking, inquiry skills, conceptual understanding and better attitudes (Deboer, 2002; Shymansky, Kyle, & Alport, 1983). As already stated in the preceding sections, there is also enough evidence, which suggests that the shortage of teaching and learning resources negatively affects students’ achievement. Therefore, the shortage of teaching and learning resources presents one of the major contributing factors to students’ poor performance in science in Malawi.

Class sizes

The shortage of teachers has resulted into very large classes and heavy teaching-loads for teachers, who resort to passive instructional approaches. As a result, students have low levels of motivation, develop negative attitudes toward science subjects, and consequently perform poorly in the sciences. Like elsewhere, there is a gender disparity in performance between boys and girls in science and mathematics in Malawi (Mbano, 2003). In a study that investigated factors adversely affecting the performance of girls as compared to boys in junior secondary physical science in Malawi, Kamwendo (1984) found that both boys and girls held negative attitudes toward the subject and perceived it as difficult and irrelevant to their future careers. However, this study revealed that only girls perceived the physical science prescribed textbook as difficult and registered low participation in physical science lessons. These findings supported earlier findings by Nkaonja (1982). In her evaluation study of the UNESCO primary science pilot
project in Malawi, NKAONJA (1982) also found that large classes made it difficult to teach science effectively, and about two-thirds of the subjects perceived science as difficult. Additionally, Nkaonja found that pupils had low levels of understanding of science topics taught in a second language (English), and teachers were forced to translate lessons into a local language (Chichewa). Nkaonja further observed that while students found it difficult to understand science taught in English, translating lessons into a local language made teaching time consuming and burdensome.

Summary

The conditions in Malawian educational system are not favorable to the provision of a quality science education for the population, and to the attainment of stipulated goals for science education. Like in many developing countries, the status of science education in Malawi needs improvement if it is to benefit the majority of unemployed population in improving their livelihood outside school. Many African countries are now beginning to realize the important role science and technology play in socio-economic development, and are heavily investing in these fields (Savage & Naidoo, 2002). If Malawi is to keep pace with the developments in the region and participate actively in the global village, efforts should be made to revitalize science education. Innovations related to teacher preparation, and the provision of resources in schools should be identified to solve the problems of teacher shortage and lack of teaching and learning materials, respectively. The government should promote the diffusion TALULAR instructional innovation, which appears to promise a viable and sustainable solution to the shortage of teaching and learning resources in Malawi’s public schools.
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TALULAR Instructional innovation

Background information

The origin of TALULAR was conceptualized by Andy Byers when he was working as a VSO volunteer in Nigeria, West Africa, and it became a fully-fledged idea when he came to Malawi in 1994. Byers was motivated by the observation that many teachers could not meaningfully teach their subject matter content because of the lack or shortage of resources in schools. Recognizing this as a lame excuse, he argued that teachers could use resources available in their immediate environment in place of the scarce and expensive commercially-based resources. According to Byers, ‘resources’ is a richer word than ‘materials’ because it encompasses not only material things but also human and animal objects, and non-material things (Chilora et al., 2003). In 1994, Byres coined the acronym, TALULAR, for teaching and learning using locally available resources. The ministry of education in Malawi saw this as a very important innovation in the context of the problem of shortage of teaching and learning resources in schools, and through the Malawi Institute of Education, has embarked on a campaign to encourage teacher to utilize TALULAR in their routine instructional practices in public primary and secondary schools in Malawi (MoESC, 2001). In this campaign, teachers are called upon to be assertive in identifying, designing, developing, and utilizing locally available resources to improve the quality of teaching and learning in Malawi’s schools. The campaign comes in line with a policy statement number 2 under section 4.2.5 of the Policy Investment Framework document, which states, in part, that teacher training on the utilization of locally available resources shall be of crucial importance in teacher training programs (MoESC, 2001). Even though this policy statement seems to be particularly directed at teacher training programs at primary school level, teacher training on the utilization of locally available resources have also
been done to both pre-service and in-service secondary school teachers over the past years. It would have been helpful, however, if the ministry of education had clear policy guidelines about the innovation for both primary and secondary school teachers to show their commitment to the innovation.

**Perceived benefits of TALULAR**

According to experts of the innovation, TALULAR is seen to have a number of potential benefits if implemented effectively. Chilora (2003) and MIE (2004) highlighted some of these benefits. First, the use of TALULAR in the classroom encourages learner creativity. Since the use of TALULAR for teaching may involve design or creation and development before utilization of resources in the classroom, the entire process teachers go through enables them see how they can motivate learners to be creative in their thinking. This implies that teachers should move from passive instructional strategies and embrace those that encourage active learner involvement in the learning process, and provide learners with authentic resources and activities to facilitate knowledge construction. Second, the use of TALULAR motivates learners. Since locally available resources are within learners’ everyday experience, utilizing them helps to elicit learners’ attention and interest, and students are likely to find topics relevant. At the same time, it is easy to gain learners’ attention when the subject matter is relevant to their local environment. Third, since locally available resources are accessible from ones immediate environment, using TALULAR is cost effective as compared to relying on industry-produced resources, which are usually very costly and unsustainable. Fourth, the use of TALULAR arouses learner curiosity. Since some of the resources for TALULAR are likely to be new or unusual to students as far as classroom learning is concerned, and such resources may not completely explain or demonstrate the underlying scientific principles, learners are likely to be thrown into disequilibrium. Their
curiosity will be evoked and will make them to explore more in search of meaning and understanding. In the process, students are likely to develop deeper levels of understanding of content. Fifth, use of TALULAR promotes students’ memory. As the Chinese Proverb says, ‘I hear I forget, I see I remember, I do I understand’, by using TALULAR learners are given the opportunity to handle, manipulate, observe, experiment, and describe thereby facilitating rehearsal of information which improves their ability for long-term storage and eventual recall. In light of these benefits associated with TALULAR, the ministry of education hopes that if teachers could adopt and implement the innovation, the quality of education could significantly improve.

In summary, if TALULAR is successfully implemented by teachers in their routine instructional practices, students’ understanding and performance are likely to improve. In addition, utilizing TALULAR is cost-effective and sustainable. While recognizing that most teachers are overloaded with teaching load due to understaffing, it is not feasible to expect teachers to teach the entire curricula using TALULAR. Utilization of TALULAR demands extra time for creating, developing and planning on the part of teachers. Therefore, successful implementation of TALULAR for teaching depends on the availability of industrial-based resources as complementary resources.

Empirical studies on TALULAR innovation in Malawi

Despite the potential benefits of TALULAR described in the preceding section, little research has been done on this instructional innovation. Specifically, studies informed by diffusion of innovations theory that can provide valuable information to stakeholders in planning, diffusing, and managing the innovation are apparently rare. A few authors have talked about TALULAR although their main purpose did not focus on the innovation.
IEQ/Malawi (2003) conducted a longitudinal exploratory study using both qualitative and quantitative (survey) data in which the focus was on: (1) the experiences of primary school pupils as they progressed from grade to grade, (2) the factors that influence their learning, and (3) the learning environment of both the teachers and the pupils. The study followed a cohort of pupils from grades 1-4 of their primary school cycle from 1999 to 2002. One of the major findings was that most teachers, irrespective of their professional qualification, utilized accessible homemade teaching materials (TALULAR) and textbooks.

A survey among primary school teacher trainers (tutors) in teacher training colleges in Malawi showed that although the innovation was used less frequently, tutors had a positive attitude towards the innovation and acknowledged its potential benefits (Kadzera, 2006). In the same vein, in her qualitative case study which in part sought to examine whether or not the six primary schools science teachers’ teaching practices were in line with what they were expected of, and what they were taught during teacher preparation programs, Kalande (2006) reported that primary school science teachers in Malawi also acknowledged the potential benefits of the innovation even though it was used less frequently in their instructional practices.

These studies did not focus on TALULAR in relation to secondary school science teaching nor were they informed by the diffusion of innovations theory. As such, their findings may not be generalized to secondary science teachers nor do they provide change agencies and agents with important information about innovation factors important in the implementation of TALULAR by secondary school science teachers. However, they do provide insights into how favorably teacher training college tutors and primary school science teachers perceive the innovation as an important and alternative solution to the shortage of teaching and learning.
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resources. In addition, findings of these studies provide an impression to change agents that the innovation is not only unsuccessfully implemented but is also infrequently used.

Relationship between DOI theory and TALULAR

Most of the innovations discussed by Rogers’s (2003) DOI theory are technological in nature. He defined technology as “a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome” (p.13). As he further explained, this definition implies that there should be a problem first before identifying a tool for addressing it. He emphasized that technology encompasses both material (such as a desktop) as well as immaterial objects, such as knowledge and procedures. Rogers’ definition of technology is consistent with Deweyan conception of technology. Dewey in Hickman (1992) defined technology as, “a family of methods and tools that evolves in response to the needs and goals that it is called upon to serve, and in response to the uses to which it is put” (p.61). Like Rogers (2003), tools for Dewey not only included material objects such as books, computers, TV, electronic networks, and other digital technological products, but also included immaterial objects such as knowledge, skill, language, theories, and so forth (Hickman, 1992). Therefore, technology should not be looked at in a narrow sense to mean commercially produced hardware and software, networking, the Internet, the World Wide Web, and other digital technologies. Looking at technology in its broadest sense, TALULAR is also a technological innovation aimed at addressing instructional and learning problems related to inadequate or lack of teaching and learning resources in Malawi’s public schools.

TALULAR is an innovation, according to Rogers’s (2003) DOI theory, because it is an idea or practice that is perceived as new by teachers in Malawi. Therefore, the DOI theory would provide a useful framework for understanding the diffusion of the innovation among science
teachers. First, the DOI theory could provide a framework for understanding why TALULAR is adopted and implemented by some teachers or rejected by others. Apart from explaining the adoption and rejection, advocates of TALULAR could use DOI theory to predict factors that could potentially impede or speed up the innovation diffusion process. Second, Malawi Institute of Education (MIE), a Ministry of Education curriculum development and teacher preparation arm, and all other teacher preparation institutions and agencies would benefit from the understanding of DOI theory so that they can determine not only the best strategies to introduce the new idea to teachers but also identify the best communication channels to utilize in spreading the innovation to clients in order to ensure its adoption and implementation.

Roles of various stakeholders in the diffusion of TALULAR

Some of the stakeholders involved in the TALULAR innovation, whose roles will be discussed include the following: (a) individuals, (b) organizations, and (c) government agencies.

The role of individuals

While recognizing that there are various individuals who have a stake and are involved in the diffusion of TALULAR innovation such as teachers, students, and community members, only the role of teachers, as potential adopters or end-users of TALULAR, will be discussed.

The role of teachers. The importance of teachers’ role in the diffusion of TALULAR cannot be overemphasized. Teachers are the ones who will eventually use this innovation in the classroom and are better placed to judge its impact and limitations on teaching and students’ learning. To begin with, teachers must critically examine their goals about teaching and student learning (Eraut, 1975). This critical evaluation of their goals and the current situation of education in Malawi will help them realize that there is a gap between what education is supposed to achieve and the current situation on the ground. As already highlighted in the
preceding sections, one of the contributing factors to the poor quality of education in Malawi is the inadequate or lack of teaching and learning resources. It is only when teachers see a gap between their goals and actual outcomes that they will consider an innovation to be relevant (Eraut, 1976; Rogers, 2003). In absence of this need, teachers will otherwise consider themselves already functionally coordinated and view TALULAR as unnecessary.

Teachers must also know and understand what this innovation is all about. To do this, they must pay attention to messages from interpersonal communication channels about the innovation (Rogers, 2003). Teachers need to take advantage of workshops or professional development meetings in which the use of TALULAR is demonstrated (G.H. Zembeni, personal communication, February 14, 2007). Such workshops will provide opportunities to learn more about the innovation, evaluate its potential benefits and perceived complexity, and learn how to effectively identify, create, modify, and utilize local resources for teaching and learning.

Ultimately, teachers will become their own change agents rather than relying on professional change agents (Rogers, 2003). As already pointed out, the ability of clients to evaluate an innovation is positively related to adoption (Rogers, 2003). Teachers who have acquired the technical competence in using TALULAR and adopted this idea should act as role models to their peers in incorporating this idea into their daily instructional practices so that others can observe the use of the innovation and its results, and try it out on a limited basis. According to diffusion research, the observability and trialability of an innovation is positively related to the rate of adoption (Rogers, 2003) and implementation (Hughes & Keith, 1980).

An innovation entails change as opposed to mere dissemination of awareness knowledge about the innovation (Eraut, 1975). Hannafin and Savenye (1993) attributed the observed teacher resistance to adopting instructional technologies in their teaching to their tendency to adhere to
traditional teaching styles, which include emphasis on lecturing, avoiding discussion groups, and utilizing the chalkboard as the principal tool for teaching. Therefore, the TALULAR innovation calls for teachers to have positive attitudes towards change; change in their long-held and practiced passive instructional strategies (Kalande, 2006; Lungu, 2005), and embrace student-centered approaches (Chilora et al., 2003). However, it should be noted, according to Handal (2004), that “teachers’ instructional beliefs reflect personal theories of knowledge and knowing” (p.2). Trying to alter their methods of teaching entails changing their habits, and ultimately their identify (Dewey in Hickman, 1992). For the TALULAR innovation to be successful, teachers must be self-initiative, resourceful and invest their time and effort to identify locally available resources from their communities, design and develop them for instructional purposes. This demands that teachers should begin to view themselves as resource providers rather than waiting for the government alone to provide all the needed resources.

Role of organizations

While there are many organizations involved in the diffusion of TALULAR in Malawi, for the purpose of this paper, the role of the following organizations will be highlighted: schools, non-governmental organizations (NGOs), and teacher preparation institutions.

The role of schools. Considering head teachers in schools as both administrators and leaders, they play a significant role in the diffusion of TALULAR. Bennis and Nanus (2003) provided important characteristics of effective and successful leaders. First, they work hard to make sure that those not willing to move in the same direction are persuaded to do so if they can’t model his or her behavior. Second, effective leaders inspire and do not direct. Third, they appeal and cultivate everyone’s commitment, and fourth, they do not control but empower members of the organization.
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According to G. H. Zembeni, many head teachers are exposed to the TALULAR innovation earlier as opposed to teachers because they are invited to training workshops with the hope that they will be eventually pass on the knowledge and skills to teachers in their own schools (personal communication, February 14, 2007). According to diffusion theory, head teachers are expected to be role models and use TALULAR so that other teachers could be able to observe the results of using it and quell uncertainties and eventually imitate the expected behavior. Instead of making individual decisions and rules, and expecting teacher compliance, head teachers need to involve teachers in decision-making about what is expected of teachers in relation to the innovation. Organizations which put great emphasis on requiring their members to observe rules and procedures (formalization) has been found to be negatively related to innovativeness (Rogers, 2003; Sultan & Chan, 2000). When teachers are involved in making decisions related to TALULAR, they will be empowered and will anticipate to be held accountable for using or not using the innovation.

There is empirical evidence, which shows that organizations with a culture that values and emphasizes teamwork, and allows a wider participation of its members in decision making and holding them accountable influences the adoption of innovations (Sultan & Chan, 2000). While head teachers or principals are responsible for communicating innovation information to teachers in their schools, their heterophily with teachers may impede effective communication and jeopardize adoption (Rogers, 2003; Yates, 2001). Therefore, the head teacher’s role should be to identify teachers within their schools who possess opinion leadership characteristics and delegate them to represent them during innovation workshops or orientation fora. These teachers could be effective role models and their homophily with members of the social system will influence buy in of the new idea by peers. When members of staff from within the school are
actively involved in activities and decisions related to the innovation, they develop ownership of
the innovation, and through staff development programs done at a school level, schools will be
able to develop their own resource as teachers become experts and trainers for their peers
(Stevens, 2004).

Head teachers as leaders also have a responsibility to develop positive attitudes towards
the innovation and to persuade other members, especially opinion leaders, to adopt the new idea
by highlighting its benefits. Evidence shows that the use of persuasion facilitates decision-
making process by potential adopters (Attewell, 1992; Barker, 2004; Rogers, 2003). Similarly, in
his meta-analysis, Damanpour (1991) found that adoption of innovations is facilitated when
managerial personnel have positive attitudes toward change and are supportive to members of
the organization thereby creating a conducive environment for the new idea.

*The role of teacher preparation institutions.* The importance of ensuring that
teachers are well-prepared to better deal with classroom demands is well documented (Darling-
Hammond & Baratz-Snowden, 2005; Griffin, 1999; Pushkin, 2001). For teachers to effectively
utilize resources, and employ participatory instructional methods that have proven effective in
fostering learning, it is uncontested that teacher preparation institutions have a vital role in
ensuring that prospective teachers are adequately prepared. The main teacher preparation
institutions in Malawi include: Teacher Training Colleges, Domasi College of Education, Mzuzu
University, and the constituent colleges of the University of Malawi: Chancellor College, Bunda
College of Agriculture, and Malawi Polytechnic. The major role these institutions should play in
the diffusion of TALULAR is three-fold: (a) adopt the TALULAR innovation, (b) incorporate
the innovation into the education curricula and train pre-service teachers about the innovation,
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and (c) enforce the use of the innovation among pre-service teachers during teaching practice before they are certified.

When teacher training faculty adopt the innovation, and integrate it in their daily instructional practices, they will act as effective role models and send a signal to teacher trainees that the innovation is beneficial and worth their effort. Teachers will vicariously observe how such ideas are utilized by instructors and how they contribute to their own understanding of concepts. From these demonstrations, teacher trainees will acquire knowledge and skills needed to effectively utilize new ideas in their own situation. According to diffusion theory, potential adopters adopt new ideas when they can observe results, and emulate opinion leaders (Rogers, 2003). Some teacher preparation institutions have not taken a lead in training pre-service teachers about the innovation despite being aware of its potential benefits. Stevens (2004) highlighted two important areas in which teacher development institutions could better prepare teachers by ensuring that teachers’ long-term needs related to the innovation are addressed. First, he suggested that training should focus more on measurable effects as outcomes of classroom instruction. Stevens contended that teachers should be trained that they themselves and students will be able to realize some well-defined practical benefits associated with the innovation if they utilize it effectively in their instruction. In other words, teachers should know how the innovation will benefit them and their students, and should be able to tell when the expected outcomes are realized or not.

Second, to achieve successful innovation implementation, Stevens (2004) advocated preparing teachers with adequate knowledge of theory and principles about how humans learn and how instruction influences such learning. Steven’s observation was in support of Rother (2003) who suggested that although technical know how is important, teacher preparation
programs should not only put emphasis on training technical skills to the exclusion of training teachers on the alignment of technology with curriculum and pedagogical principles. Hernandez-Ramos (2005) went further to point out that it is a mistake to assume that if teachers have the needed technical skills they will automatically integrate instructional innovations in the classroom. He further argued that teachers have different instructional beliefs, which also play a key role in instructional decisions they make, and therefore, emphasis should be on pedagogical knowledge as opposed to technical skills, and reforming instructional and learning beliefs held by them. Dexter, Anderson and Becker (1999) contended that, “For teachers to implement any new instructional strategy, they must acquire new knowledge about it and then weave this together with the demands of the curriculum, classroom management, and existing instructional skills” (p.223).

Therefore, teacher preparation programs targeting pre-service teachers and training workshops for in-service teachers should strike a balance between innovation technical skills and theoretical principles that enlighten pedagogy so that teachers could begin to see the connection between the innovation, classroom application, and how students are likely to benefit from the implementation of the innovation in their instruction. Any training that does not address theoretical principles on which instructional strategies are derived is likely to be perceived as irrelevant. Mouza (2002-2003) observed that innovation training that is irrelevant to classroom practice, in any professional development, is one of the major obstacles to innovation use.

*The role of NGOs.* NGOs have for a long time played a significant role in uplifting educational standards in Malawi. They have been involved in funding teacher preparation programs and workshops designed to orient teachers on new curricula, and providing teaching and learning materials. Some of these NGOs include: United Stated Agency for International
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Development (USAID), United Kingdom Department of International Development (DFID), Deutsche Gesellschaft fur Technishe Zusammenarbeit (GTZ), Creative Centre for Community Mobilisation (CRECOM), UNICEF, and others. According to G.H. Zembeni, a few organizations have taken a leading role in facilitating the diffusion of TALULAR in various ways (personal communication, February, 14, 2007). GTZ, a German-based NGO, and UNICEF have each funded and organized separate orientation workshops on TALULAR for college tutors, who are responsible for preparing pre-service and pre-service primary teachers. CRECOM took part in mobilizing communities to support the TALULAR initiative by collecting and bringing various resources to their primary schools. USAID funded the production of TALULAR users guide for primary school teachers through its IEQ and MESA initiatives (Chilora, et al., 2003). The Japanese government funded an in-service training program for secondary school science and mathematics teachers (SMASSE) in which the use of TALULAR was part and parcel of the training goals (L.L. Likoswe, personal communication, November 29, 2007). It is evident that the activities by most NGOs highlighted here have focused much on basic education, and little attention has been given to training secondary schools teachers. While their roles are restricted by their mission objectives, efforts should be made towards training secondary school teachers, especially those in community day secondary schools (CDSSs), where the majority of teachers are unqualified and teaching and learning resources are unavailable. These teachers need to acquire essential knowledge, skills, and dispositions to effectively utilize TALULAR.

NGOs could also help in the diffusion of TALULAR by working with schools and government agencies to identify and train opinion leaders so that the diffusion of TALULAR is decentralized to individual schools or schools clusters. By working with primary education advisors (PEAs), principal and senior education method advisors (PEMA and SEMA), and
education method advisors (EMAs), NGOs can also facilitate the adoption and implementation of TALULAR by providing incentives to teachers who have adopted and effectively use the innovation.

**Role of government agencies**

In this section, key government agencies whose roles in TALULAR diffusion will be discussed briefly. Such agencies include: The Ministry of Education (MoE), Malawi Institute of Education (MIE), Department of Teacher Education (DTED), Teacher Development Centers (TDCs), and the Education Divisions (EDs).

The MoE is responsible for planning, development, and management of education in Malawi. MIE and DTED are the arms of the ministry of education responsible for curriculum issues and teacher education, respectively. The ministry’s role is very crucial in the diffusion of the innovation, and should increase the level of its involvement in this campaign (G.H. Zembeni, personal communication, February 14, 2007). While the ministry recognizes the potential benefits and supports the innovation, as evidenced by the policy statement in the Policy Investment Framework (PIF) document (MoESC, 2001), it should be in the forefront to devise strategies that would facilitate the diffusion process. It should also enforce the use of the innovation by all teachers. Through DTED and MIE, the ministry should also increase training opportunities for teachers, increase the number of diffusion centers, provide incentives to users, and increase innovation information accessibility by using both mass-media channels (such as TV and radio) and inter-personal channels. Policy enforcement could be decentralized so that primary education advisors and education method advisors in each education division are responsible for teacher supervision and proving ongoing support services to teachers. Zhao and Frank (2003) observed that support services rendered to teachers when learning instructional
innovations do influence adoption (Zhao & Frank, 2003). Currently, teacher training and orientation of TALULAR is highly centralized and done at MIE where only one person, Mr. Zembeni, is the active expert in TALULAR. Centralization of an innovation has been found to be negatively related to the innovation diffusion process (Damanpour, 1991; Rogers, 2003). Therefore, for the diffusion of TALULAR to be accelerated, many more training centers should be established throughout the country, and more change agents and opinion leaders should be trained and deployed in these local centers to facilitate the diffusion processes. In this way, there will be more trained people in the field and the innovation process will be facilitated due to the establishment of interpersonal networks (Ely, 1989). The diversity of specialists in the organization (high specialization) has been found to positively influence adoption through the division of labor and the provision of a broader knowledge base (Damanpour, 1991).

The MoE could also boost the rate of adoption and implementation of TALULAR among teachers by providing incentives in the form of promotions, fringe benefits, and formal recognition. Providing incentives to potential adopters has been found to be positively associated with the rate of innovation adoption (Chapman, 2003; Klein & Sorra, 1996; Rogers, 1973; Stacy & Sally, 1999). However, caution should be exercised when giving incentives as it may negatively affect innovation sustainability and may result in low quality adoption (Rogers, 2003).

During training, emphasis should be on highlighting factors critical to innovation adoption such as enabling change agents acquire adequate technical know how (Rogers, 2003), as well demonstrating how the innovation fits into both curricula and pedagogy (Rother, 2003).

**Summary**

The TALULAR innovation advocates for a radical change in the way teachers in developing countries view and make use of resources that are locally available in their near
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environment. Teachers as end-users of TALULAR innovation play a very important role in ensuring that the innovation is adopted and implemented. They are the ones who will eventually utilize the innovation in the classroom and judge its actual benefits and limitations in teaching and learning. According to Stevens (2004), teachers shoulder the blame for not fully implementing new ideas or when new ideas are unsuccessful. It is important, therefore, that they are accorded opportunities to try new ideas and given continuous support to ensure implementation and institutionalization of the innovation. For the innovation to be institutionalized, the ministry of education should commit itself to teacher development and mobilize its resources towards the diffusion campaign to ensure that more teachers adopt and implement it. Stevens (2004) clearly articulated the importance of teachers’ perceived commitment of relevant stakeholders in developing and securing the resources related to the innovation, and the resulting implications on teachers’ willingness and motivation to try it out:

Quite simply, teachers perceive the [school] district as being serious about the innovation if they commit resources to it. It suggests that the innovation is more permanent and that it may not be just another thing that will come and go in a couple of years. As a result teachers may be more inclined to put their time and effort into trying the innovation.

(p.393)

If teachers perceive that their schools, education divisions, and the ministry of education are not seriously committed to the innovation diffusion process, even those who have adopted or implemented it will be unmotivated and reject or discontinue its use.

Teacher preparation programs are well positioned to facilitate the diffusion process by ensuring that pre-service teachers are introduced to the idea before they are certified. If trained early, these teachers models as well as change agents to their peers when deployed to their job
settings. For this to happen, tutors and lecturers (professors) responsible for methodology courses at these institutions should model the use of TALULAR so that pre-service teachers could imitate them and see how such resources could best be used in their own situation.

Demographic and employment variables relevant to the implementation of TALULAR

In this section, teachers’ demographic and employment variables, as they relate to innovation adoption and implementation, will be briefly reviewed. Available literature on these variables seems to focus more on computer technology adoption in higher educational institutions as an instructional tool. Because some of these studies looked at adoption in terms of usage of innovations, such literature will be used to discuss relevant variables and their potential influence on implementation of TALULAR.

Training

According to Rogers’ DOI theory, end-users of innovations still have uncertainties during implementation stage when an innovation has been adopted (Rogers, 2003). According to Rogers, it is during implementation stage that issues about how exactly the innovation works, how to use it, and how its use will affect them arise. One of the most important facilitating conditions for innovation implementation is knowledge and skills (Ely, 1990, 1999a, 1999b). The purpose of innovation training is to ensure that end-users acquire knowledge and skills associated with innovation (Klein and Sorrrra, 1996), and empirical evidence has shown that training directly and significantly influences innovation implementation (Aiman-Smith and Green, 2002; Hubbard and Ottoson, 1997). In general, training related to innovations has been found to be an important ingredient for successful innovation diffusion (Armstrong, 1996; Beggs, 2000; Groves & Zemel, 2000; Jacobsen, 1998; Jacobson & Weller, 1988; McCormick et al., 1995).
Bauer and Kenton (2005) argued that teachers’ classroom activities mirror the kind of training they went through, and adequately prepared teachers are expected to use innovations intensively and extensively. In his descriptive analysis, Banks (2002) observed that the faculty training model offered by the Faculty Development Institute (FDI) at Virginia Tech was an exemplary and successful model of formal training program to assist faculty integrate computer technology in their teaching. As a suggestion for improvement in this model, Banks recommended conducting an assessment of faculty needs and expectations prior to training, and addressing these needs and expectations rather than just introducing them to technology. Therefore, a well planned and executed training not only aids in reducing uncertainties associated with the innovation but also helps targeted organizational members to use it more effectively, and generally perceive the innovation as having greater relative advantage, compatibility, simplicity, observability and trialability.

Another training variable that has been found to be an important determinant of innovation implementation is the amount of training or length of training. Stevens (2004) argued that for implementation of instructional innovations in school to be successful, adequate amount of training for end-users is required. He reiterated that one-day training workshops are destined to innovation implementation failure, and often times stakeholders tend to attribute such failure to ineffectiveness of innovation rather than to training ineffectiveness. Empirical evidence has also shown that the observed difference among end-users in their reported level of innovation implementation (measured by frequency of use) is significantly and positively related to the amount of training received (Eylon & Bagno, 1997; Wozney, Venkatesh & Abrami, 2006). In other words, longer training periods tend to provide adequate time for end-users to acquire essential knowledge and skills to effectively implement and management innovations.
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In this study, training will be included as a study variable and it is expected that it will be an important determinant of TALULAR implementation. In addition, it is predicted that teachers who have had lengthy TALULAR training will tend to perceive the innovation more favorably and use it more frequently.

Level of education

In the context of TALULAR, secondary school science teachers have varying levels of qualifications and a greater proportion of less qualified teachers are in community day secondary schools. As already pointed out in preceding sections, the number of years of college training or education is related to student achievement (Fuller, 1987). This suggests that teachers, who have a higher level of qualification, spent more years of training, are well versed in both content and pedagogy, and are more likely to be confident and effective in their teaching (Darling-Hammond, 1997; Darling-Hammond & Baratz-Snowden, 2005). In particular, African teachers who are not well prepared have negative attitudes toward science teaching (Salisbury, 1985). In a study that used a mixed-method approach to examine teacher instructional practices using computer technology as an instructional tool, and to identify obstacles they overcame in the process of using the innovation, Bauer (2005) found that teachers who were highly educated and skilled with technology were more innovative and more proficient at overcoming obstacles associated with implementing the innovation. However, contrary to the researcher’s expectations, these teachers did not use the innovation on a daily basis, and attributed this to their students’ lack of adequate time with computers, and their own lack of adequate planning time.

According to Rogers’ DOI theory, individuals who are more educated or have more years of formal education are more innovative than others (Rogers, 2003), and adequate formal education has been found to enable targeted organizational members to develop favorable attitudes that
facilitate the acceptance of innovations (Waller, Hoy, Henderson, Stinner & Welty, 1998; Caswell, Fuglie, Ingram, Jans & Kascak, 2001).

Contradicting Rogers’ (2003) hypothesized positive relationship between the level of education and individual adoption behavior, findings in a survey-based study that sought to determine faculty members’ adoption behavior in a web-based distance education in China showed that there was a significant and negative influence of education on faculty members’ stages in the innovation-decision process (Li and Lindner, 2007). Li and Lindner’s findings supported those by Harper, Rister, Mjelde, Drees, and Way (1990), who also found that the level of education was negatively related to adoption of an agricultural technological innovation among Texas rice producers. Contradicting these findings, Doss and Morris (2001) found that education positively influenced the adoption of an agricultural innovation among farmers in Ghana. In another study that investigated the underlying psychological factors that influenced the adoption of innovative teaching practices and new instructional technologies by both faculty and graduate teaching assistants (GTAs) in higher education, Watson (2007) found that participants had similar teaching with technology self-efficacy regardless of the level of education or degree held. Watson’s findings supported earlier and related findings by Chapman (2003). Chapman’s study sought, among other goals, to assess and identify factors that influence business teacher educators to adopt and use computer technology methods in their instruction. One of the major findings revealed no evidence that participants’ integration of computer technology in their instruction practices differed by their level of education.

While empirical studies on the relationship between innovation implementation and the level of education are apparently scarce, and their results seem to contradict, a number of studies have looked at the relationship between the level of education and innovation adoption.
However, findings on the influence of the level of education on adoption are also contradictory. On the other hand, the studies reported here were either done on agricultural innovations or computer technology in higher education contexts and their findings may not generalize to other contexts. Since adoption does not always translate into implementation, this study will, therefore, examine the relationship between level of education and implementation, and its value in predicting the implementation of TALULAR in the context of secondary school science education in Malawi. It is expected that teachers with a higher level of education will be more likely to implement TALULAR in their instructional practices.

*Teaching experience*

Schultz (1975) argued that education and experience are two important but distinct elements that individuals use to deal with and manage change. Sultan and Chau (2000) defined experience as “encounters that one undergoes or lives through” (p. 109). Perkins and Rao (1990) found that more experienced organizational members tend to be more involved in innovation-related decisions, and eventually begin to perceive themselves as more capable of making such decisions than those with little experience. Furthermore, experienced individuals are more likely to look for more information about the innovation while at the same time focus on the most relevant and valuable information (Chiesi, Spillich & Voss, 1979). While it is conceivable that experience may affect the acceptance of innovation in a way desired by change agents, it should be noted that experience may also influence adoption or implementation negatively (Caswell et al., 2001). Caswell et al. further argued that while more experienced members may be more efficient in acquiring new ideas, and more effective in integrating them in their routine practices, experience may also be a stumbling block to enabling long-serving members relinquish their long-cherished practices and embrace new ones.
In a quantitative study that investigated the relationships among teacher experience, efficacy, and attitudes towards the implementation of a cooperative instructional innovation among middle and high school teachers, teachers’ experience was negatively related to ratings of the importance of implementing the innovation, and was positively correlated with their ratings of difficulty of incorporating the innovation in their teaching (Ghaith et al., 1997). This means that the more experienced teachers were in their teaching profession, the less important they considered implementing it, and the more difficult they tended to perceive its implementation. In the same vein, a study that sought to understand how Ohio farmers made decisions to adopt or reject new ideas, and how their decisions were related to their educational background, Waller et al (1998) found that less experienced growers, who tended to be younger, were more willing to try new agricultural ideas. Supporting these findings, Adams (2002) examined teachers’ concerns related to technology integration in their instruction and compared these concerns with demographic and professional variables of 231 surveyed part-time-and full-time faculty at a post secondary institution. Findings revealed that faculty members who were less experienced (≤ 3 years of experience) expressed significantly higher computer integration in their instructional practices compared to those with more teaching experience. On the other hand, Watson (2007) found that teaching with technology self-efficacy among faculty and teaching assistants at a higher education institution did not differ significantly by their teaching experience. Findings by Watson supported those by Chapman (2003) who also found no significant differences in computer technology integration between genders for the 38 business teacher educators who returned that survey.

Contradicting the preceding findings, and supporting Rogers’ (2003) findings, a study that sought to determine higher education faculty adoption behaviors about web-based distance
education in higher education, teaching experience was significantly and positively related to faculty adoption behaviors (Li & Lindner, 2007).

In summary, a review of literature indicates that study findings tend to contradict on the relationship between experience and innovation adoption and implementation. While some studies have found experience to be a significant predictor of innovation adoption and usage, others have revealed that it may be a significant hindrance to end-users’ acceptance and willingness to try and incorporate new ideas in their practices. Despite this inconsistency, study findings tend to suggest that experience is negatively related to innovation implementation. In this study, experience will be included as a study variable, and it is expected that more experienced teachers will tend to stick to their old ways of teaching and perceive TALULAR unfavorably, and will be less likely to use it in their teaching than the less experienced ones.

**Gender**

A review of literature on the influence of gender on the use of computer technology innovations indicates contradictory findings. Watson’s (2007) study described in the preceding section, found that female faculty and teaching assistants had less technology teaching self-efficacy than their male counterparts. The implication of this finding is that females are less likely to adopt and implement computer technology innovations in their instruction than their male counterparts. In fact, findings by Ghaith et al.(1997) indicated that 25 middle school and high school teachers, who participated in an in-service training program at the American University of Beirut, Lebanon) and had a higher personal teaching efficacy, perceived a cooperative instructional innovation to be more compatible with their existing practices, and less difficult to implement.
Adams (2002), who examined faculty members’ concerns related to technology integration in their instruction, and compared these concerns with demographic and professional variables, found a significant relationship between gender and the level of technology integration. Specifically, the level of technology integration by female faculty was significantly higher than their male counterparts. Similar findings were also reported in a recent study by Wozney et al. (2006), who investigated the relationship among motivational, instructional, and school factors that influence the nature and frequency of computer technology integration practices among elementary and secondary school teachers. Data were collected using technology implementation questionnaire, and one of the major findings was that the reported use of computer technologies for instructional purposes was significantly higher for female teachers compared to male teachers.

However, in a study where data were collected from 273 college faculty using a questionnaire, Li and Lindner (2007) found that sex was not significantly related to faculty members’ adoption and utilization of a web-based distance education approach. Other studies have also reported similar findings in which there were no significant differences in computer technology integration into teaching between male and female faculty members in higher education (Chapman, 2003; Okinaka, 1991).

Since TALULAR innovation is being studied in relationship to science education, a look at gender differences in attitudes and self-efficacy in science teaching would also shed some light into the expected differences in TALULAR implementation in the science classroom. In a study that examined gender influences on elementary school teacher attitudes, self-efficacy, and attitudes toward science teaching, Riggs (1991) found that male in-service and pre-service teachers had significantly higher science teaching self-efficacy than females. As pointed out in
the preceding sections, African teachers who are not well prepared have negative attitudes toward science (Salisbury, 1985). In the secondary school education sector in Malawi, a larger proportion of unqualified teachers are found in community day secondary schools (CDSSs) compared to conventional secondary schools (CSSs). Based on empirical evidence, which suggests that attitudes are significantly and directly related to innovation acceptance and implementation (Rao, 1994; Sooknanan et al., 2002), and the likelihood that the level of science teaching self-efficacy will influence teachers’ adoption and implementation of a science-related innovation, it was expected that female science teachers would be less likely to integrate TALULAR in their teaching than male teachers.

In summary, while most of the studies reviewed in this section related to computer technology innovations in education, it is evident that findings related to gender as a determinant of innovation adoption and implementation are inconsistent and conflicting. In this study, gender will be one of the predictor variables and its relationship to the perceived characteristics and the level of TALULAR implementation will be examined.

**Type of school where teachers were assigned**

Community day and conventional secondary schools in Malawi differ remarkably in terms of both the availability of industry-based teaching and learning resources related to science and proportions of qualified teaching staff. According to Murphy (1998), the availability of adequate resources is one of the essentials schools must have in order to achieve innovation implementation. In fact, empirical findings have consistently shown that resources are among the important conditions that facilitate innovation implementation (Ely, 1990, 1999a, 1999b; Chapman, 2003; Hubbard & Ottoson, 1997; Murphy, 1998; Surry & Ely, 2002, Surry & Ensminger, 2003). It should be noted that TALULAR is meant to complement the already
existing industry-produced curricula resources financed by the ministry of education. This means that the burden to implement TALULAR for teachers in schools that have relatively adequate teaching and learning resources is much less compared to those in schools where the problem of resources is more serious. Due to the foregoing, it was expected that teachers in CDSSs, where the problem of shortage of teaching and learning resources for science is very critical, will have unfavorable perceptions about TALULAR and report low levels of implementation.

In summary, studies on implementation tend to support the importance of resources in facilitating implementation of innovations in schools. Relevant stakeholders should, therefore, ensure the availability and accessibility of essential resources related to the innovation if successful implementation is to be achieved by end-users.

*Overall summary of the review of literature*

From the review of related literature, it is evident that Rogers’ diffusion of innovations theory is a useful theoretical framework for understanding, planning, and managing the innovation diffusion process. Particularly, it provides valuable information that would guide change agencies and agents in utilizing workable strategies to ensure that innovations in the field of instructions technology are not only adopted, but more importantly, implemented. Surry and Ely (2002) also indicated that the trend in diffusion research seems to shift from innovation adoption toward important topics of implementation and institutionalization. Sooknanan et al. (2002) also highlighted this paradigm shift by pointing out that the most important question about innovations in diffusion of innovations research today is how to attain successful innovation implementation once they have been adopted. This paradigm shift is considered worthwhile because of the realization that most innovations fail not necessarily because they are not adopted or are irrelevant, but because of the challenge to achieve successful implementation.
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(Klein & Sorra, 1996). Despite this shift in diffusion studies, scholars have long bemoaned the general paucity of innovation implementation research based on diffusion of innovations theory (Klein et al., 1996; Surry et al., 1998; Rogers, 1983).

For the field of instructional technology, now commonly referred to as instructional design and technology (IDT), Surry et al. (1998), and Surry et al. (2002) recommended studies that focus on determining factors important in the implementation of innovations. Among the important features of Rogers’ DOI theory, the perceived characteristics of innovations are among the innovation factors or variables that have extensively been studied in previous diffusion research. With the shift from innovation adoption to implementation, scholars have continued to examine the relationship between these perceived characteristics of innovations and innovation implementation.

This review of literature has revealed that studies that draw explicitly from Rogers’ DOI theory, especially on the five main attributes of innovations as implementation predictor or explanatory variables, are seemingly rare. Those that closely attempted to do so were either done in non-educational settings (Goldman, 1994; Kaluzny et al., 1974), and their findings may not generalize across settings. In the same vein, a number of studies on perceived characteristics of innovations as factors in innovation implementation have found inconsistent and conflicting findings making it impossible to draw meaningful conclusions (Dass, 2001, Goldman, 1994; Hughes et al., 1980; Morris, 1985). Despite these inconsistent findings, attributes of compatibility, relative advantage, and complexity have been found to be the most consistent determinants of innovation adoption-implementation (Tornatzky et al., 1982).

Conflicting findings in diffusion studies on the perceived characteristics of innovations as they relate to implementation of innovations has been attributed to methodological flaws in most
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studies. One of the notable flaws is the tendency for scholars to operationalize many attributes far beyond those specified by Rogers and Shoemaker (1973) and Rogers (1983, 1995, 2003). There is need for studies that draw explicitly from Rogers’ main attributes and investigate their predictive or explanatory value on various innovation implementations in order to permit meaningful comparisons of findings across contexts. In addition, many innovation implementation studies are case studies utilizing varying methodological approaches and end up identifying varying sources of implementation success or failure.

Rogers (1995) observed that “one of the possible problems with measuring the five attributes of innovations is that they may not in all cases be the five most important perceived characteristics for a particular set of respondents” (p.209). This implies that the perceived characteristics of innovations are context-dependent. Therefore, this study will attempt to examine science teachers’ perceptions in addition to other variables that may be important and unique to the context of TALULAR implementation in Malawi. An attempt will be made to reduce the number of perceived characteristics and include those perceived characteristics that have explicitly evolved from Rogers’ original main attributes of innovations.

Studies that have examined whether or not end-users’ demographic and employment variables (such as gender, level of education, experience,) as significant determinants of innovation adoption and implementation have also yielded conflicting findings. On the other hand, there is a general consensus among scholars that access to training (and the amount of training), and the availability and access to resources are significant determinants of innovation implementation. Specifically, training directly influences implementation and is thought to influence implementation through shaping the way end-users perceive the characteristics of innovations, such as the perceptions of relative advantage, complexity, compatibility, and
trailability. While attitudes towards innovations that are associated with gender differences among science teachers may influence implementation directly, they may also shape how end-users may perceive the characteristics of a science instructional innovation. It is important, therefore, to control for training and gender in assessing the collective value of innovation factors (perceptions of innovations) in accounting for variance in innovation implementation. Previous studies have not considered controlling for the effects of gender, level of education, experience, and training when studying the predictive or explanatory value of Rogers’ five attributes of innovations on implementation. Because such studies may have overestimated the accounted variance in adoption and implementation, this study will compare the predictive value of these innovation attributes before and after demographic and employment variables have been accounted for.

A review of the status of education and science education in Malawi has revealed that conditions in Malawian educational system are not favorable to the provision of quality education in general, and quality science education in particular. Like in many developing countries, the status education and science education in Malawi needs if it is to benefit the majority of unemployed population in improving their livelihood outside school.

Two key educational problems that Malawi and other governments in Sub-Saharan Africa have had to deal with since independence and continue to haunt the education sector include the following: (a) lack of adequately qualified and trained teachers, and (b) inadequate supply of teaching and learning resources. The expansion of primary education and the rising demand for schooling after independence brought forth formidable challenges not only in the primary education sector but also in the post-primary education systems. Many African countries may have learned the hard way that comprehensive expansion of education should be done
systematically and holistically for the entire educational system if the quality of education is to be upheld. Comprehensive expansion of education should include but not limited to the construction of adequate classrooms, the production and supply of an adequate number of well qualified and trained teaching force, and the provision of adequate teaching and learning resources at levels of the education system.

The persistence of the preceding problems in Malawian schools casts doubt on the government’s commitment to ensuring that the stipulated goals of education and science education are attained. The fundamental problem for most African countries has been the growing conflict between the ever-rising enrollments and the dwindling of resources (Fuller & Heyneman, 1989). This has rendered these nations incapable of adequately financing their education, and has led to the subsequent erosion of the quality of education. It is unlikely, however, that many African countries will experience economic boom in a short term, and the provision of a quality education depends on identifying educational innovations that will raise the quality of schooling. Innovative ways are, therefore, required in areas of teacher recruitment and preparation, and teaching and learning resources.

While the ministry of education should be applauded for making strides in alleviating the problem of shortage of qualified teachers by utilizing innovative ways of teacher preparation and certification, much remains to be done to address the problem of shortage of teaching and learning resources in schools. Therefore, innovations like TALULAR that are aimed at solving this problem have a great potential in revolutionizing education in low-income nations and contributing to improved quality of education. This innovation promises a viable and sustainable solution to the shortage of teaching and learning resources. Even if African countries could manage to solve the problem of the shortage of qualified teachers, the provision of a quality
science education will remain a myth, and many problems highlighted in this section will continue to haunt the educational systems for decades to come if long-term solutions to the problem of teaching and learning resources are not found. The government is, therefore, called upon to mobilize its resources in support of TALULAR diffusion process to ensure that it is implemented by teachers, in general, and secondary school science teachers, in particular.

Despite the potential benefits of TALULAR innovation to revitalize secondary school science, the review of literature has also revealed that studies that have examined the diffusion of TALULAR, let alone the implementation of TALULAR among secondary school science teachers, are apparently non-existent. A few studies, in which TALULAR has been mentioned, either involved primary school teacher trainers (Kadzera, 2006) or primary school science teachers (Kalande, 2006). Since these studies did not focus on TALULAR and were not informed by the diffusion of innovations theory, their findings may not be generalized to secondary science teachers nor do they provide change agents with important information about factors important in the implementation of the innovation by secondary school science teachers. However, they do provide insights into how favorably teacher training college tutors, and primary school science teachers view TALULAR as an important solution to the shortage of teaching and learning resources. Findings from these studies also inform change agents that the innovation is not only unsuccessfullly implemented but is also infrequently used by teachers in their instructional practices.

**Purpose of study**

The purpose of this study is two-fold: (1) to determine whether, and to what extent, the perceived characteristics of innovations and teachers’ demographic and employment variables
are useful in predicting the implementation of TALULAR, and (2) to determine the extent to which TALULAR has been implemented by secondary school science teachers in Malawi.

Research questions

From a review of literature, this study seeks to answer the following nine specific questions: (1) What is the relationship between the perceived attributes of using TALULAR innovation and the level of implementation? (2) Do the attributes of innovations have any utility value in predicting the implementation of TALULAR either independently or collectively? (3) What are the relationships among teacher demographic and employment variables (such as gender, level of education, teaching experience, training, and school type) and the implementation of TALULAR? (4) Controlling for teacher demographic and employment variables, can the perceptions of innovations together significantly predict the implementation of TALULAR? (5) What is the most parsimonious model that could be used to optimize the prediction of the level of TALULAR implementation when perceived characteristics, and demographic and employment variables are considered together? (6) Are there differences in the perceptions of using TALULAR and the level of implementation by gender, level of education, experience, type of school, training, and length of training? (7) Are there differences in teachers’ perceived characteristics of using TALULAR depending on the frequency of use? (8) To what extent has the TALULAR innovation been implemented by secondary school science teachers in their instructional practices since the launch of the diffusion campaign around 1997? (9) What are the major concerns among secondary school science teachers regarding the innovation?

Significance of the study

The ministry of education, through teacher training institutions and other agencies, has been involved in training teachers, especially in-service teachers, on the usefulness of the
TALULAR and how to effectively implement it in their classrooms. Since the beginning of the diffusion campaign around 1997, there has been little if any information about: (a) the extent to which the innovation has been implemented by secondary school science teachers, and (b) the evaluation of the diffusion campaign to identify areas in the diffusion process that need improvement to facilitate adoption and subsequent implementation. This study will, therefore, furnish decision makers, change agencies and agents with information on the extent to which the innovation has been implemented by secondary school science teachers. The results of this study will also highlight critical factors, based on Rogers’ diffusion of innovations theory, which could significantly predict the implementation of the innovation in science subjects in which it is needed the most. Such factors could be used by decision makers not only in planning a successful diffusion campaign, but also in predicting future implementation levels of similar instructional innovations and put in place interventions for potential adopters identified as at risk for low implementation.

The five attributes of innovations in relation to adoption and implementation have mostly been studied in light of industry-based technologies such as computer use in the classroom (Sooknanan et al., 2002; Chapman, 2003), Internet (Gardner & Amoroso, 2004), software programs (Feeney, 2005; Issac, Rajendran & Anantharaman, 2006), and information systems (Yetton, Sharma & Southon, 1999). Such studies were done in contexts where organizations invested huge sums of money to acquire such innovations. In such cases, end-users were held accountable for the use of the innovation and may have been forced by top managers to adopt and implement them. The present study provides a new context for studying the perceptions of innovations very different from the ones under which most previous studies were carried out. First, the use of the innovation is not known to be either voluntary or mandatory, and
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one is unaware if teachers expect to be held accountable to higher authorities for failure to adopt or implement it in their classrooms. However, their use or nonuse of the innovation could affect the quality of their evaluation of teaching effectiveness when being supervised by education method advisors. Such teaching effectiveness appraisals could affect teachers as promotional decisions may partly be based on such evaluation reports. Second, the innovation is neither made available for use in the schools nor does the ministry of education invest a lot in acquiring resources related to the innovation. The entire responsibility is left in the hands of individual teachers who have to look around in their immediate environment to identify and/or modify, design, and develop locally available resources for use in their classrooms.

Previous studies have also tended to operationalize excessively more and potentially confounding innovation attributes, and have found inconsistent findings. This study will test the significance of perceptions of innovations that explicitly evolved from Rogers’ five original perceived characteristics in the prediction of TALULAR implementation. Since this study is done in an educational setting in a developing country, it will provide a basis for comparison of findings across contexts. Additionally, the study will contribute information to the paucity of empirical studies on the implementation of instructional innovations in secondary school science education using Rogers’ perceived attributes of innovations.
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Chapter 3: Methodology

The purpose of this study was two-fold: (1) to determine whether, and to what extent perceived characteristics of innovations (relative advantage, compatibility, complexity, trialability, observability, voluntariness, and mage) and teachers’ demographic and employment variables were useful in predicting implementation levels of TALULAR, and (2) to determine the extent to which the TALULAR innovation has been implemented by secondary school science teachers in Malawi. Among other things, findings of this study will provide information useful to change agencies and agents in planning a successful TALULAR diffusion campaign. Additionally, this study will provide cumulative empirical evidence not only on the relationship between perceived characteristics of innovations and innovation implementation, but also on the usefulness of these perceived attributes of innovations in predicting implementation of innovations.

Research questions

The research questions that guided this study are as follows: (1) What is the relationship between perceived attributes of using TALULAR and the level of implementation? (2) Do the attributes of innovations have any utility value in predicting the implementation of TALULAR either independently or collectively? (3) What are the relationships among teacher demographic and employment variables (such as gender, level of education, teaching experience, training, and type of school) and the implementation of TALULAR? (4) Controlling for teacher demographic and employment variables, can the perceptions of innovations together significantly predict the implementation of TALULAR? (5) What is the most parsimonious model that could be used to optimize the prediction of the level of TALULAR implementation when perceived characteristics, demographic and employment variables are considered together? (6) Are there
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differences in the perceptions of using TALULAR and the level of its implementation by gender, level of education, experience, type of school, training, and length of training? (7) Are there differences in teachers’ perceived characteristics of using TALULAR depending on the frequency of use? (8) To what extent has the TALULAR innovation been implemented by secondary school science teachers in their instructional practices since the launch of the diffusion campaign around 1997? (9) What are the major concerns among secondary school science teachers regarding the innovation?

This chapter describes the methods employed to answer the research questions, the research design, study population, sample and sampling procedures, instruments for collecting data, data collection procedures, field test, and the statistical techniques used to analyze data.

**Design of the study**

This investigation falls in the category of non-experimental exploratory studies; it is a non-experimental study in the sense that neither random assignment nor variable manipulation was involved (Pedhazur, 1997). The study utilized a cross-sectional survey design to gather data using a questionnaire from one sample at one time (McMillan, 2004). For diffusion of innovation studies, “surveys may be methodologically adequate as they permit replicability and some degree of cross-study comparability, and can provide a basis for generalizing about the innovation process” (Tornatzky & Klein, 1982. p.29). In addition, Isaac and Michael (1990) argued that surveys are the most widely used methods of data collection in education and behavioral sciences for describing attitudes, perceptions and opinions.

**Population**

The target population for this study consisted of both male and female serving secondary school science teachers in community day secondary schools (CDSSs) and conventional
secondary schools (CSSs) in the northern region of Malawi. Science subjects taught by these teachers were teaching were restricted to the following: (a) Physical Science, (b) Biology, and (c) Agriculture. These teachers were located in public secondary schools within six districts that make up the northern region of Malawi. These districts were: Mzimba, Likoma Island, Nkhata-Bay, Rumphi, Karonga, and Chitipa. It should be noted that CSSc, as used in this study, included both grant-aided secondary schools and generic/conventional secondary schools, and CDSSs included both approved and non-approved schools. While the Northern Education Division did not have readily available statistics on the total number of science teachers, it was approximated that there were about 800 science teachers teaching these subjects in a total of 189 schools in the northern region of Malawi. This estimate of the number of science teachers was based on the average number of science teachers that were found in each school, that is, on average, each community day secondary school (CDSS) had 4 science teachers while each conventional secondary school (CSS) had an average of 6 science teachers.

Participants and criteria for recruitment

Because of limited resources (both time and money), it was not possible to collect data from all science teachers in all secondary schools in the northern region of Malawi. For this reason, a smaller, but representative group of science teachers was sampled to participate in this study. In order to draw a feasible but representative sample from this population, a few criteria guided the recruitment process. Regardless of gender, science teachers teaching Physical Science, Biology, and Agriculture in the Northern Region public secondary schools were targeted. In addition, all full time science teachers serving in public CDSSs and CSSs irrespective of their educational qualifications, teaching experience, political affiliation, age, tribe, and district of origin constituted the sample. These criteria for selecting participants
ensured that the resulting sample was more representative of the larger population of science teachers from both the two categories of public secondary schools (CDSS and CSSs) in the Northern Region. Questionnaires were either distributed or sent to 44% ($n = 350$) of the entire population of about 800 science teachers. 271 science teachers from 71 schools in the northern region participated in this study, completed and returned the questionnaires. It should be noted that the sample size was based on rules of thumb in literature that suggest the acceptable minimum number of subjects per predictor especially in multiple regression analyses. For instance, authors have recommended the following subject-to-variable ratios to be sufficient: 15 subjects per predictor, that is 15:1 (Park & Dudycha see Osborne, 2000, 1974; Pedhazur, 1997; Stevens, 1986), 20:1 (The Trustees of Princeton University, 2007), 30:1 (Pedhazur & Schmelkin, 1991; Pedhazur, 1997), 40:1 (Cohen & Cohen, 1983; Tabachnick & Fidell, 1996), and others have suggested a minimum total of sample of 400 (Pedhazur, 1997). Because of the evident variability in these recommendations (ranging from 15:1 to up to 40:1), an average subject-per-variable ratio of 26:1 was computed and became the basis for determining an appropriate sample size for this study. The 300 targeted participants, and hence the 269 usable responses (discussed below), were therefore, deemed sufficient for the initial number of variables (10 variables) in this study. Of the 271 responses, 2 were eliminated from data analysis because it was determined that one participant completed two questions as evidenced by identical handwritings on two questionnaires from the same school. The other participant completed very few questions in part II of the questionnaire on perceptions of the TALULAR innovation. As a result, data from 269 cases (representing approximately 34% of the entire population of science teachers) were actually used for the analysis. Table 2 presents summative information relating to the demographics of the participants. Of the remaining 269 participants, 225 were male (84%) and
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44 were female (16%). Their ages in years ranged from 20 to over 60 with a mean age range of 36-40, and a majority of them (76.8%) were within the age range of 26-40 years. Of the 296 participants, 97 of them (36%) were teaching in CDSSs while 172 (64%) were teaching in CSSs. Their mean number of years of teaching experience was a range of 7-10. In terms of their education qualifications, 87 (32.3%) had MSCE, 99 (36.8%) were diploma holders, 81 (30.1%) had a bachelor’s degree, and .4% \(^n=1\) had a Masters degree and another .4% \(^n=1\) had other qualification (which was specified as O Level GCE offered in London, an equivalence of MSCE). Those teachers with an MSCE certificate (equivalent to high school diploma in American education system) are considered unqualified or under-qualified. Of these under-qualified teachers, a majority of them (98.8%, \(n=84\)) taught at CDSSs and only 1.2% \(n=1\) taught at a CSS.

**Sampling procedure**

When the study was being designed, the researcher had knowledge that the northern education division office would not have a comprehensive sampling frame of all science teachers in CSSs and CDSSs. However, they had an inclusive list of all schools in the division.

Stratified random sampling was used to select participants from the population. Schools in which teachers taught were stratified according to the two main types (CDSS and CSS) and location (urban and rural). Urban schools were those that were within the bounds of Mzuzu City and all other schools were considered rural. Schools in each stratum were randomly selected using a table of random numbers. Because the numbers of science teachers were expected to be relatively lower, and that a relatively larger sample was recommended for the design of this study, all science teachers from each randomly selected school constituted the study sample. Participants were drawn from 10 urban schools and 61 rural schools. Stratification of schools...
was based on the observation that resources available may vary with the school type and location. Through the work of parent teacher associations, urban schools are likely receive more donations from the urban working community and non-governmental organizations than those in rural locations. In addition, urban schools are more accessible to donor agencies than their rural counterparts. In the same vein, most CDSSs have a critical shortage of teaching and learning resources compared to CSSs. The reasons, as explained in earlier sections, are historical in nature. Before Malawi adopted a Free Primary Education (FPE) policy in 1994, CDSSs used to be distance education centers (DECs) with very limited resources in general, and no laboratories in particular. Due to the swelling enrolment numbers as a result of the FPE, these DECs (even though resources were limited) were converted to what are now called CDSSs. The researcher believed that variations in resources among schools were likely to influence implementation of the TALULAR innovation among secondary school science teachers. In fact, there is empirical evidence which suggest that resource availability is one of the facilitating conditions for innovation implementation (Ely, 1990, 1999a, 1999b; Hubbard & Ottoson, 1997; Murphy, 1998). After the schools were selected, the researcher visited the schools to meet with the participants. During such visits, participants were briefed on the purpose and significance of the study and asked them to participate. All science teachers, in each school sampled, were very willing to participate.

Instrumentation and study variables

To answer the research questions, a survey questionnaire was deemed to be best suited to collect data from participants. Gall, Borg and Gall (1996) asserted that surveys are not only the most effective and efficient means of gathering data from a large dispersed population such as the one in this study, but they are also an accurate way of gathering such data.
The instrument for measuring teachers’ perceived characteristics of using TALULAR innovation (the predictor variables) was adapted from an existing instrument developed by Compeau, Meister and Higgins (2007). This instrument had adequate validity and reliability information. Compeau’s et al. instrument drew extensively on measures developed by Moore and Benbasat (1991). Some items for Compeau’s instrument came from Moore (1989) and Karahanna (2006), and yet others were developed by the researchers themselves for aspects of constructs that were not adequately covered. Originally, Rogers (2003) specified five main constructs (relative advantage, compatibility, ease of use or complexity, observability, and trialability) as perceived attributes of innovations, which were later refined by Moore et al (1991) into 8 constructs. Relative advantage was decomposed into two constructs: relative advantage and image; Observability was decomposed into two constructs: visibility and result demonstrability; and they added another construct, perceived voluntariness. Compeau et al. further refined the constructs operationalized by Moore and Benbasat (1991) into 11 separate constructs (but later dropped one construct, compatibility with preferred work style). The progression in refining Rogers’ original constructs is summarized in the Figure 3. Campeau’s et al. further refinement, development and validation of the original broader perceived characteristics of innovation constructs as originally defined by Rogers (2003) improved the specificity of these constructs. Compeau et al. (2007) also argued that the refined measures were more adaptable for use in different technological contexts.
It is important to note that perceptions as defined by Rogers were based on potential adopters’ perceived attributes of the innovation itself rather than on perceptions of actually using it, which are most important in innovation diffusion (Moore et al, 1991). Therefore, the revisions and refinements of these constructs in instrument published by Moore et al. (1991) and later by Compeau et al. (2007) were helpful in moving away from the problem of focusing on using primary attributes of innovations as research variables to focusing on secondary attributes that are considered to have the greatest effect on innovation acceptance behavior (Moore et al., 1991).

These measures had acceptable internal consistency reliability with alpha values ranging from 0.80 to 0.96, exceeding the commonly acceptable minimum threshold value of 0.70.
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(Nunnally, 1978). Except for compatibility with preferred work style, which was removed from the list after the final validation process, all constructs demonstrated both convergent and discriminant validity. In addition, the measures were content validated through card sorting by experts with a reported Cohen’s Kappa of 0.76. In their final field testing of the instrument, Compeau et al. (2007) removed measures for compatibility with preferred work style because of discriminant validity problems with measures related to relative advantage construct.

For the purposes of this study, a pool of items that were field-tested by the authors and retained during their final analysis, were selected and modified. The modifications mainly involved changing the name of the innovation by replacing ‘hospital computer system’, which Compeau et al. (2007) studied with ‘TALULAR’. In addition, some items that were negatively worded in the original instrument were positively worded to help participants not to misread the items. In fact, the items that were mostly deleted by Compeau et al. were negatively worded as they were misread by respondents and resulted into erroneous responses. It should also be mentioned here that in some cases where it was determined that participants were likely to have problems comprehending the items, the structure of such items was also modified. This involved replacing terms that were perceived to be difficult with ones that were likely to be simple for some participants of this study. For instance, an item that measured perceived complexity or simplicity of the innovation originally read as follows: “I believe that the hospital computer system is cumbersome to use” was changed to, “I believe that TALULAR is very involving to use”. Six new items were created, and five more were added from Moore and Benbasat (1991) for constructs that had fewer items and in some cases where it was determined that items relevant to TALULAR innovation context were important. Appendix E shows a list of items that made up the instrument for measuring perceived characteristics of using TALULAR innovation including
those that were adapted from the original source and the new ones that were added. Definitions for innovation constructs are presented in Appendix F.

Teachers’ perceived characteristics of using TALULAR innovation were measured by a total of 61 items on a 5-point Likert scale ranging from strongly agree (coded 5) to strongly disagree (coded 1). Of these 61 items, six were newly created items, five were taken from Moore and Benbasat (1991) and 50 were taken from the original instrument developed by Compeau et al. (2007). These measures of perceived characteristics of using TALULAR made up part II of the survey questionnaire (see Appendix D for a complete questionnaire).

Part I of the survey began with four items that elicited background information about TALULAR innovation. These items sought information about science subjects the participants were teaching, whether or not there was a need for TALULAR, and whether or not participants had adopted the innovation and if they were using it or not. These questions were followed by two more questions that measured frequency of usage of TALULAR. Implementation as a criterion variable was measured by innovation utilization (frequency of use). In the early stages of implementation, when an innovation has not been routinized or institutionalized, “usage is the only available measure of implementation success” (Yetton et al., 1999, p.58). For innovations where use is voluntary, as might be the case with TALULAR, Barki and Huff (1985) recommended measuring implementation in terms of innovation usage too. Davis (1989) also used usage as a measure of innovation acceptance by asking respondents to self-report their degree of current usage of the innovation using scales with the following categories: (a) don't use at all, (b) use less than once each week, (c) use about once each week, (d) use several times a week, (e) use about once each day, and (f) use several times each day. Other authors used satisfaction with the innovation and utilization (frequency of use) as measures of implementation.
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(Sooknanan et al., 2002; Rao, 1994). Inclusion of satisfaction as a measure of implementation (the criterion variable) has the potential of confounding results as relative advantage (a predictor variable) could also be measured in terms of convenience or satisfaction (Greenhalgh et al. 2005). Therefore, usage was an appropriate measure of implementation as the focus of this study was not to measure the quality of use of TALULAR innovation. For the two Likert-type items that were created to measure the frequency with which science teachers used of TALULAR, frequency of use was measured on a five-point scale. The first item measured frequency of use per day on a five-point scale as follows: Do not use at all, once a day, 2 times a day, 3 times a day, and more than 4 times a day. The second item measured frequency of usage per week on the following scales: Do not use at all, 1-5 times a week, 6-10 times a week, 11-15 times a week, and more than 15 times a week. Asking the exact number of times the innovation was used was deemed appropriate in order to elicit precise rather than inaccurate and general responses.

The last section (part III) of the questionnaire asked participants to report their demographic and employment information, and other school-related information such as teaching load, class sizes, number of textbooks, status of innovation training, and areas of concern regarding the innovation. While most questions were very structured, some question were open-ended in order to allow participants to elaborate on their responses hence ensuring that data collected was not only more accurate but also more valid.

Pilot study

Before data for the main study were collected, a pilot study was conducted in May 2008, in the South Eastern part of Malawi with a population of science (Physical Science, Biology, and Agriculture) and Mathematics teachers in both Conventional Secondary Schools (CSS) and Community Day Secondary Schools (CDSS) in the South Eastern Education Division in Zomba.
Municipality. The purpose of the pilot study was to gather information to help improve the overall quality of the survey instrument by identifying and correcting any technical, grammatical, typographical errors, and any ambiguous terms in the items. Permission to conduct a field test was obtained from the education division manager in Zomba. Non-proportional quota sampling was used to select participants for the study. When resource constraints limit the selection of a probability sample, quota sampling enables one to select participants from existing profiles of subgroups in the population to come up with a sample that is more representative of the population (McMillan, 2004). This sampling procedure ensured that participants from CDSSs and CSSs in both rural and urban areas (without necessarily drawing equal sample sizes) were represented in the sample. Trochim (2006) likened this non-probabilistic sampling to stratified random sampling owing to the fact that it ensures that smaller subgroups are adequately represented in the sample.

A total of sixteen teachers participated in the pilot study. Of these, 31.3% ($n=5$) were female and 68.8% ($n=11$) were male, and 56.3% were CDSS teachers while 43.8% were CSS teachers. In terms of their educational background, 12.5% had a Malawi School Certificate of Education (MSCE), 62.5% had a diploma, and 25.0% had a bachelor’s degree. All participants completed a questionnaire which had items for the main study and items that sought evaluative information about the survey. In general, participants felt that: (a) the questions were clear, (b) the overall length of the questionnaire was average (neither too short nor too long), and (c) that some items on perceived characteristics of TALULAR innovation were repetitive or redundant.

Based on the feedback from the pilot test a number of revisions were made to the survey instrument. The meaning of the acronym TALULAR was included in part I of the survey because some participants felt that including the meaning of TALULAR was important in
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avoiding confusion especially for new teachers just joining the teaching profession. Part II of the survey contained an instrument for collecting data about teachers’ perceptions of using TALULAR. Participants thought that a number of items conceptually measured the same thing and considered them erroneously redundant. These questions were repeated intentionally by design to check participants’ consistency of their responses. To ensure that participants in the main study answered all questions even though some appeared to be redundant, a statement was included in this section of the questionnaire that alerted participants of this situation and emphasized the need to answer all questions. Some changes involved reducing the space where participants were supposed to enter their written responses after it was determined that some responses to items required little space. This also helped reduce the overall length of the questionnaire.

Data collection procedure

This study was first approved by the Virginia Tech’s Institutional Review Board (IRB) that ensures research protocols involving human subjects are ethical and that the rights of participants are protected (see IRB certificate in Appendix A). Before data were collected in the study sites, written permission was sought from the education division manager for the Northern Education Division and from the ministry of education in Malawi (see Appendix B).

Data collection began towards the end of June 2008 and was completed by the end of July 2008. Each school that was sampled was visited, and as an official procedure, the researcher first reported to the head teachers or school principals (or their deputies if the head teachers were not present). These school administrators were briefed about the study and a copy of the written permission form the ministry of education was handed to them to show that the study had the blessing of their employer. During these briefings, the researcher emphasized the importance of
the study and reviewed instructions for completing the survey, which were to be conveyed to all science teachers present at each school. In addition, heads were also informed to convey to participants that participation was voluntary and they had the right to withdraw from the study at any time. Head teachers were also requested to distribute one questionnaire to each science teacher teaching Physical Science, Biology and Agriculture at their schools. If the head teachers were teaching any of these science subjects, they were also requested to complete a questionnaire. It should be mentioned here that data collection was done during a period where secondary schools were in session, and teachers were busy teaching or administering end of semester exams. As such, it was only convenient to ask head teachers to distribute the surveys to participants whenever they availed themselves. However, in some instances, the researcher had opportunities to talk with participants and extended a plea for their participation. Though visiting each of the sampled schools was not-cost-effective, it was considered the most reliable and effective means of ensuring a higher response rate in a relatively shorter period of time as compared to mailing the questionnaires. For schools where it was problematic to reach because of impassable roads (like Chitipa district schools) or required travelling by local and unsafe boats across lake Malawi (like Likoma Island schools), I sent the questionnaires to schools through people who worked in government institutions travelling to or living around those schools. In such cases, a cover letter, a stamped envelop, and written permission from the ministry of education was sent together with the questionnaires. Out of the a total 350 questionnaires that were distributed, only 55 were send indirectly through third parties some of whom were head teachers in the neighboring schools.

Once questionnaires were sent or distributed, follow-ups were made through telephone calls to head teachers to check whether or not participants had completed them. When most or all
participants had completed them, the researcher travelled to those schools to collect them. On average, it took between one to two weeks for questionnaires to be completed and be ready for collection. Responses from those that were sent through a third party were either mailed or send back through a third party. In total, 271 questionnaires were completed by participants and returned to the researcher.

Data analysis techniques

Descriptive statistics were used to describe participants’ demographic and employment variables, their perceptions of TALULAR innovation, and levels of implementation of TALULAR as a teaching tool. Descriptive statistics help to organize and summarize data using numbers in a way that it is simple to understand characteristics of the sample (Gall, Gall & Borg, 1999). To investigate any associations between each of perceived characteristics of TALULAR innovation and implementation, and associations between demographic and employment variables and implementation, bivariate correlations using Pearson Product-Moment Correlation Coefficient (r) were used.

Multiple regression was used to determine the relationships between innovation factors (perceived characteristics of TALULAR, and participants’ demographic and employment variables) that influence teachers’ implementation of TALULAR. Multiple regression is an appropriate statistical technique for analyzing separate and collective effects of predictor variables on a criterion variable (Pedhazur, 1997). According to Ross and Morris (2004), multiple regression can also be used to determine relative contributions of each predictor variable in accounting for variance in the criterion variable.

Simultaneous, hierarchical or sequential, and stepwise regression analyses were be used as statistical methods of data analysis. Even though simultaneous regression is typically used in
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explanatory studies, Keith (2006) argued that since explanation subsumes prediction, simultaneous regression can also be used for predictive purposes where one can use results to determine the relative importance of various predictor variables by examining standardized regression coefficients. For this reason, simultaneous regression was used to determine the extent to which perceived characteristics of innovations collectively and separately predicted the level of TALULAR implementation.

Hierarchical regression, also called sequential regression analysis, is appropriate when variables selection is theory based (Pedhazur, 1997). In a hierarchical multiple regression, the researcher decides not only how many predictors to enter but also the order in which they enter, and usually, the order of entry is based on logical or theoretical considerations (Keith, 2006; Pedhazur, 1997). Keith further argued that in determining the order of entry of variables, “one common defensible solution is to input the variables in order of presumed or actual time precedence…and beyond actual time precedence and logic, previous research can also help make such decisions” (Keith, 2006, p.81). Hierarchical regression was used to control for demographic and employment variables when assessing the collective value of the perceived characteristics of TALULAR in predicting the level of implementation. Apart from effects of demographic and employment variables occurring earlier in time sequence as compared to perceived characteristics of innovations as they relate to implementation of TALULAR, from a review of literature, these variables were thought to influence implementation indirectly by shaping end-users’ perceptions as they used the innovation. Therefore, these demographic and employment variables were controlled for in order to assess the predictive value of perceptions of innovations alone. In this case, however, it would have been illegitimate to use regressions coefficients in assessing the relative contributions of predictor variables (Pedhazur, 1997). In other words, such
an analysis was not intended to provide information about the relative importance of predictor
variables, but rather, it was meant to furnish information about the amount of variance in
implementation these variables were able to account for after having controlled for demographics
and employment variables.

Stepwise regression is used for purposes of pure prediction without much regard to
variables selection procedures based on theory (Keith, 2006), and the goal is to maximize the
accounted variance or $R^2$ squared (Pedhazur, 1997). When stepwise regression is used, regression
coefficients are not interpreted as indices of effects. However, Pedzahur argues that predictability
is maximized when variables have been identified based on theoretical considerations. Stepwise
regression was used to come up with a parsimonious model that would optimize the prediction of
implementation when all variables (demographic and employment variables and perceptions of
innovations) were considered together. These variables were selected partly based on
theoretically underpinnings and partly based on previous research. This procedure helped to
determine, under such constraints, the best combination of variables in order to maximize the
prediction of TALULAR implementation among secondary school science teachers.

Magnitudes of effects were measured in terms of percent of variance explained, and
magnitude of standardized regression coefficients where simultaneous regression analysis was
used (Keith, 2006). Kinnear and Gray (2008) offered a rough guide (based on eta squared in
ANOVA) as a classification of effect sizes in multiple regression. Values of $0.01 > \eta^2 \geq 0.10$, and $R^2 > 0.10$, reflect, small, medium and large effect sizes, respectively. In ANOVA,
magnitude of effect sizes were measured by the statistic eta squared ($\eta^2$). Values of $0.06 \leq \eta^2 < 0.14$, and $\eta^2 \geq 0.14$, reflect small, medium, and large effect sizes,
respectively (Kinnear et al., 2008). In t tests, magnitude of effects were examined by computing
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Cohen’s measure, $d$ (Cohen, 1988, as cited in Kinnear and Gray, 2008). Values of $0.2 \leq d < 0.5$, $0.5 \leq d < 0.8$, and $d \geq 0.8$, reflect small, medium, and large effect sizes, respectively.

Categorical independent variables were dummy-coded so that they could be meaningfully used in multiple regression. Dummy coding allows categorical variables to reflect some continuum, and to allow their coefficients (parameter estimates) to be interpreted as incremental differences in the dependent variable (Sweet & Grace-Martin, 2003). Pearson correlation was used to measure magnitudes of relationships or associations among variables.

Independent-sample $t$ tests were used to compare whether significant differences existed between two group means on gender, and school type, and a one-way ANOVA was used to compare more than two group means (e.g., level of education, amount of TALULAR training, and teaching experience) on implementation and perceptions. Where ANOVA on the comparison of more than two group means was significant, a follow-up multiple comparison test was performed to identify the exact location of the difference (Ross & Morris, 2004). To identify which means were different, Tukey’s multiple comparison procedure, a post hoc comparison test, was conducted. According to Howell (2007), Tukey’s HSD test is follow-up comparison test of group means which is a commonly used pairwise test because it is not only more sensitive for pairwise differences but is also a recommended procedure for priori comparisons than Scheffe test. Even though Scheffe test is highly regarded, it is considered to be over-conservative in as far as pairwise comparisons are concerned (Kinnear & Gray, 2008). To determine the level of TALULAR implementation, the mean implementation score was computed and a one-sample t test was used to determine whether such a mean was significantly different from the ‘never use TALULAR at all’ category. In this statistical test, the ‘never use at all’ group were coded 1 and this value was used as a test value. In addition, proportions of science teachers who reported
using the innovation were computed and used in determining the level of implementation. The minimal critical level for the test of statistical significance (alpha) for all analyses was set at .05 (p ≤ .05).
Chapter 4: Results

This chapter presents the findings of the study. First, a brief overview of data collected is provided followed an analysis of its quality in terms of internal consistency reliability and validity. Demographic and employment variables of participants are described in detail, and the chapter ends with a presentation of findings for each of the nine research questions.

Overview of data collected

The survey instrument for the main study was designed to collect three types of data. The first portion (part I) of the survey (questions 1-3) gathered data on the science subjects taught by the respondents, and established the need for the TALULAR innovation. Need for the innovation was established by an item requiring a “yes” or “no” response, followed by an open-ended question that required an explanation. This section also gathered data on whether or not respondents had adopted (accepted) the innovation, and whether or not they were using it in their teaching. These items required “yes” or “no” responses as well. The last two items (questions 5 and 6) in this section collected data on the level of implementation of the innovation by requiring respondents to self-report the frequency of innovation usage per day and per week. These were Likert-type items with a five-point rating scale ranging from “1” for ‘do not use at all’ to “5” for ‘more than 4 times a day’ for item 5, and “1” for ‘do not use at all’ and to “5” for ‘more than 15 times a week’ for item 6. The level of implementation was operationalized as follows: 1: No implementation (do not use at all), 2: Low level of implementation (1-5 times a week), 3: Moderate implementation (6-10 times a week), 4: High level of implementation (11-15 times a week or greater than 15 times a week).

Part II of the survey gathered data on science teachers’ perceptions of using TALULAR innovation. There were a total 61 Likert-type items with five-point rating scales, ranging from
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“1” for strongly disagree (SD) to “5” for strongly agree (SA), and “3” for neutral (N) or not sure.

Part III of the survey mainly collected demographic and employment information about respondents. There were also a few open-ended items that asked participants about their concerns regarding the use of the innovation and the number and adequacy of recommended textbooks in their schools.

Data quality: Validity and reliability

The quality of data collected was established through provisions for validity and reliability. This section will begin by providing brief descriptions of the response rate, data screening, and the decisions that were made on the data set to improve data quality. Then, a detailed discussion on validity and reliability will be presented.

Response rate

As pointed out in the methodology section, 271 of the 350 surveys that were sent out or distributed were completed and returned, representing an initial return rate of 77.4%. Of these, 269 were usable, which constituted a final return rate of 77%. Babbie (1990) argued that a 50% response rate is sufficient for statistical analyses and reporting, and a 60% return rate is considered good. Conversely, McMillan (2004) maintained that when response rate is 50% to 60% or lower, the sample is considered to be biased, and external validity is greatly limited. Therefore, a return rate of 77% was considered adequate and acceptable for this study. A significant proportion of non-respondents resulted from surveys sent through a third party. For this reason, potential respondents either did not receive the surveys or they were not motivated or committed to providing their responses.
Data screening and decision-making

To ensure that the data used were of higher quality, the dataset was screened and a number of decisions were made. First, raw data were screened for any outliers, which could have undue influence on results, by scrutinizing standardized residuals greater than the absolute value of ±2. There were no standardized residuals that could have unduly influenced results. A careful look at raw data revealed a few data entry errors on perceptions of innovations for two cases, case 61 and case 2. For case 61, the response to the relative advantage item (item number 11) was scored 45 instead of 5, and for case number 2, response to the perceived voluntariness (item number 48) was scored 8 instead of 4. These were corrected by referring back to original participants’ responses on the survey. Out of the 271 completed surveys, two cases were excluded. The first one was excluded before responses were coded and data were entered into the SPSS spreadsheet. The researcher collected two questionnaires from a single school that had identical handwritings. One was in pen and the other in pencil, but responses were very similar. It was suspected that one respondent completed these two questionnaires, either because he or she misunderstood the instructions or completed one on behalf of the other who for some reason did not have time to complete one. A decision was made to discard one questionnaire and consider the other. After responses to the remaining 270 surveys were entered, one case (case number 71 with a MSCE qualification) had considerable amount missing data on perceptions of innovations. He/she did not respond to 39% (24 out of 61 items) of items in part II of the survey. As this data were integral to the study, a decision was made to delete and exclude this case in all analyses.

The level of implementation of TALULAR had two measures; one measuring frequency of innovation use per day (item 5, part I) and the other per week (item 6, part II). Of the 269
participants who provided usable responses, 7.44% \((n = 20)\) did not answer item 5, while 1.48% \((n = 4)\) did not answer item 6. All who answered item 6 also answered item 5, in other words, no participant opted to answer item 5 over item 6. This trend in responses suggested that more respondents found item 5 more irrelevant or ambiguous to respond to than item 6. A critical examination of item 5 showed that it was requesting inaccurate information, to some extent, as it was more difficult for respondents to estimate the number of times they use the innovation per day when they do not have lessons each day of the week. Therefore, question 6 was more clear and meaningful to them. Since it was believed that item 6 provided more meaningful and accurate data than item 5, a decision was made to use only data from item 6 for frequency of innovation usage.

Before the data were analyzed using multiple regression and ANOVA, checks were done to see if the underlying key assumptions for these analytical techniques were met or violated. The normality assumption in multiple regression was investigated by plotting standardized residuals (errors in prediction). The residual scatter plots showed that the majority of residuals were scattered almost evenly about the zero line and seemed to be fairly normally distributed. According to Pedhazur (1997), this pattern of residuals satisfies the homoscedacity assumption. In addition, histograms and normal probability plots provided for in SPSS showed that the data for variables did not deviate from normality. The assumption of linearity in multiple regression was tested by examining the bivariate scatter plots (and box plots) when each predictor variable was plotted on the x-axis and the criterion on the y-axis. Pedhazur (1997) also recommended plotting standardized residuals and if the “points appear to scatter randomly about the line originating from the mean of the residuals, depicting what appears to be a rectangle…” (p.36), then the linearity assumption is met. In general, all predictor variables were linearly related to the
criterion. The assumption of equal variances was satisfied by confirming that all Levene’s tests
for equality of variance were not statistically significant ($p > .05$). In addition, the assumption
regarding the normality of the dependent variable assumes that participants’ scored for each level
or group should be normally distributed around their means. When the dependent variable was
plotted against each level or group, the normal curve in each histogram showed that the
normality condition was met.

Since there were moderately high bivariate correlations between some variables such as
relative advantage and ease of use ($r = .672$), communicability and measurability ($r = .628$), and
ease of use and communicability ($r = .618$) (see Table H2 in Appendix H), it was suspected that
collinearity might be present. Although none of the bivariate correlations approached 1.00, such
suspicions were preliminarily checked by excluding one variable at a time from these pairs in the
regression model. No improvements were noted in the significance the regression coefficients for
other variables or in the overall explained variance by the revised model. As collinearity
diagnostic tool, Fox (1991) recommended examining the square root of the variance-inflation
factor (VIF). This term in the estimation of the variance of the least-squares regression
coefficient, subsumes the multiple correlation $R$ when an independent variable is regressed on
the others. Fox argued that when the square root of VIF for a particular independent variable is 2
or above, and the zero order correlations among variables are close to 1, parameter estimation for
such variables suffer from collinearity. Fox also contended that unless $R$, the multiple correlation
also called the linear relationship between one variable and all other independent variables,
approaches .9, collinearity does not adversely affect estimation. While there are countless ways
of checking collinearity, Berry and Stanley (1985) clearly isolated the most robust approach for
testing its presence:
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A preferable test for multicollinearity can be developed by recognizing the meaning of perfect multicollinearity: a situation in which regressing one independent variable on the rest produces an $R^2$ of 1.00. The most reasonable test for multicollinearity is to regress each independent variable in the equation on all other independent variables, and look at the $R^2$s for these regressions; if any are close to 1.00, there is a high degree of multicollinearity present. (p.43)

According to Berry et al. (1985), the $R^2$ test for examining multicollinearity is superior to inspecting the bivariate correlations between independent variables for the following reasons: (a) the pattern of muticollinearity is not revealed in bivariate correlations, therefore, one will hardly mistakenly reject the presence of severe multicollinearity in data, and (b) the test also isolates a group of variables that are a source of multicollinearity (or are highly linearly related). Using the $R^2$ test, it was concluded that there was no collinearity among the predictors as $R^2$ in each case ranged from .260 to .586, none of which was close to 1.00. In addition, none of the square root of the VIFs for each variable exceeded 2.

Validity

The concept of validity has traditionally been defined as the degree to which an instrument actually measures the concept it claims to measure (Slavin, 1992). Such a definition implies that validity is about an instrument or a test rather than the use of the obtained results (McMillan, 2004; Osterlind, 2006). McMillan (2004) provided a more contemporary definition of validity:

Validity is an overall evaluative judgment of the extent to which theory and empirical evidence support interpretations that are implied in given uses of the scores. In other words, validity is a judgment of the appropriateness of a measure
In this study, validity evidence was established based on two sources of validity: content and face validity. These sources of validity are discussed in the paragraphs that follow.

*Content validity.* Content validity refers to the degree to which sampled items constituting an instrument are representative of the construct or content domain being measured (McMillan, 2004). According to Osterlind (2006), expert judgment, and theory-based evidence are some of the rich sources for developing measures that have appropriate content validity. In this study, items constituting the instrument were selected based on theoretical underpinnings of Rogers’ diffusion of innovations theory and empirical evidence based on validation studies conducted by Compeau et al. (2007). As described in the methodology section, the measures used in this study for measuring perceptions of using TALULAR had adequate validity evidence (convergent and discriminant validity). In addition, they were content validated through item sorting by experts and had an acceptable level of agreement as evidenced by a Cohen’s Kappa of 0.76. The selection and development of additional items for scales that had fewer items was done based on a thorough review of literature in diffusion of innovation studies. Bohrnstedt (1983) contended that content validity could be ensured if items measuring each construct were authenticated by a comprehensive review of the literature.

A field test that was done before data collections for the main study also helped to improve validity, which is affected by systematic errors, a type of measurement errors (Crocker, et al., 1986; Streiner, 2003). Based on suggestions from pilot study participants, revisions were made to the survey that reduced systematic measurement errors by reducing ambiguities in the item structure. External validity was achieved by employing appropriate sampling procedures...
that ensured that the sample was more representative of the population (see sampling procedures under methodology section).

*Face validity.* Face validity is generally construed as the extent to which a measure appears to reflect the content or concept being measured (Byaman & Cramer, 2005). Isaac, Rajendran and Anantharaman (2006) also pointed out that face validity is based on the subjective but logical expert evaluation of the match between the items and the construct being measured. Other scholars have recommended that for those who develop new measures but can not provide other validity evidence, they should, at the very minimum, establish face validity (Bryman & Cramer, 2005). Face validity for measures used in this study was established in a number of ways. Before data were collected, the questionnaires were also reviewed by four academicians (professors) that were on my academic committee. After they reviewed them, measures were revised based on their feedback. Overall, these measures were deemed appropriate for their perceived purpose. In addition, three doctoral students, who had knowledge of the targeted respondents, and had interacted, with some of them, reviewed the questionnaires to see how appropriate they were in regard to the respondents’ level of education, context, culture and language. Feedback from these reviewers helped revise and improve the measures so that they were not only correctly worded, but also appropriate for the purpose and relevant to the context. Kaplan and Scauzzo (1993) argued that if items that constitute a measure or instrument are related to its perceived purpose in general, then face validity for the instrument has been established.

*Reliability*

Nunnally (1978) and McMillan (2004) defined reliability as the extent to which a measure is free of measurement error (random error), or the degree of consistency a measure has
in yielding the same findings when the assessment is repeated on the same construct (Slavin, 1992). McMillan (2004) and Osterlind (2006) contended that scores or results obtained by an instrument cannot be deemed to be valid unless they are reliable (McMillan, 2004, p.147). Likewise, Crocker and Algina (1986) argued that, “it would be illogical to expect measurements to be useful [valid] if we did not have some confidence that they were consistent [reliable]” (p.106).

While the original published instrument for measuring perceptions of innovations by Compeau et al. (2007) had adequate reliability evidence, Streiner (2003) recommended that scale reliability checks should be performed if measures are used on new samples. Streiner argued that alpha for the measure will always be lower if the sample used is less homogeneous than the one in the published report. In general, Streiner observed that reliability is a function of the total score variance, which varies from sample to sample. Since the sample of secondary schools science teachers was less homogenous than the one consisting of hospital non-physician employees used by Compeau et al. (2007), it was decided that reliability in this study be established. In addition, original items were reworded and a few more new ones were added. Moore and Benbasat (1991) also recommended additional reliability checks after rewording items from their instrument for use in a different context.

There are a number of procedures for establishing reliability of scores. Internal consistency reliability (coefficient alpha) was employed in this study for the following reasons: (a) it requires a single administration of a measure on a single occasion (Green, Salkind & Akey, 2000), (b) it computes reliability estimates based on the assumption that all scale items measure the same underlying content domain or construct (Green et al., 2000), or as stated by Pedhazur (1991), it is an index of both item content homogeneity with other items and item quality, and (c)
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It is “one of the most important and pervasive statistics in research involving test construction and use” (Cortina, 1993, p. 98). It should be noted that reliability speaks of item quality because in general, reliability “refers to the precision of measurement” (Pedhazur, 1997, p.34).

While Nunnally (1967) argued that satisfactory levels of reliabilities depend on the purpose for which the measure is created, he recommended alphas of .50 to .60 during early stages of research to be adequate. He further stated that, “for basic research, it can be argued that increasing reliabilities beyond 0.80 is often wasteful” (p.226), and later scaled up the minimum threshold for acceptable reliability coefficient to 0 .70 (Nunnally, 1978). This was also in agreement with the following rule of thumb on alpha levels provided by George and Mallery (2003): ≥.9 (excellent); ≥.8 (Good); ≥.7 (acceptable), ≥.6 (questionable); ≥.5 (poor); <.5 (unacceptable). Therefore, for this study, alpha of .70 was the targeted minimum criterion for accepting scales to be included in any regression analysis for which constructs were to be used as predictors.

Before PCI scales were subjected to reliability test and items analyzed using the reliability procedure, nine items for which high scores represented low scores on the perception of the TALULAR innovation (mostly ‘negatively’ worded items), were reverse scored (or recoded) so that high scores on all items represented high scores on the measured perception of the innovation. If reverse scoring is not done, as argued by Streiner (2003), items within a scale will be negatively correlated yielding an alpha coefficient that is below zero. Items that were reverse scored were as follows: Relative advantage (RAD) item 50, compatibility with prior experience (CPE) item 12, compatibility with values (CWV) item 23, ease of use (EOU) item 4, measurability (OMS) item 7, trialability (TRI) item 28, and voluntariness (VOL) items 9, 39 and
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48. Table 1 shows internal consistency reliability estimates for each construct before and after some items were deleted.

Table 1

<table>
<thead>
<tr>
<th>Scale/Construct</th>
<th>Original # of items</th>
<th>Alpha (α)</th>
<th>Deleted items</th>
<th>Alpha (α) after item deletion</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAD</td>
<td>10</td>
<td>.835</td>
<td>None</td>
<td>.835</td>
</tr>
<tr>
<td>CPE</td>
<td>5</td>
<td>.406</td>
<td>Item # 12</td>
<td>.477</td>
</tr>
<tr>
<td>CWV</td>
<td>5</td>
<td>.659</td>
<td>Item # 23</td>
<td>.705</td>
</tr>
<tr>
<td>EOU</td>
<td>8</td>
<td>.714</td>
<td>Item # 4</td>
<td>.757</td>
</tr>
<tr>
<td>OOU</td>
<td>6</td>
<td>.826</td>
<td>None</td>
<td>.826</td>
</tr>
<tr>
<td>OCM</td>
<td>4</td>
<td>.700</td>
<td>None</td>
<td>.700</td>
</tr>
<tr>
<td>OMS</td>
<td>6</td>
<td>.704</td>
<td>None</td>
<td>.704</td>
</tr>
<tr>
<td>TRI</td>
<td>6</td>
<td>.706</td>
<td>None</td>
<td>.706</td>
</tr>
<tr>
<td>VOL</td>
<td>6</td>
<td>.581</td>
<td>Item # 29</td>
<td>.594</td>
</tr>
<tr>
<td>IMA</td>
<td>5</td>
<td>.868</td>
<td>None</td>
<td>.868</td>
</tr>
</tbody>
</table>

*Note: RAD = Relative advantage; CPE = Compatibility with prior experience; CWV = Compatibility with values, EOU = Ease of use; OOU = Others’ use; OCM = Communicability; OMS = Measurability, TRI = Trialability, VOL: Voluntariness, IMA = Image. rq12 = denotes reverse scored item # 12, q29 = item # 29 (see Appendix E).*

As can be seen from Table 1, the coefficient alpha ranged from .406 to .868 when all items were included and before items were subjected to item analysis using the reliability procedure. CPE and VOL had the lowest measures of internal consistency reliability. Since the coefficient alpha measures internal consistency by looking at inter-correlations among scale
items, items that were not highly correlated with their respective scales, or had low correlations with the sum of the other items in a scale (expressed as the Corrected Item-Total Correlations) were candidates for deletion. In addition, poor quality items that were either negatively correlated with other items within the same scale and/or would increase Cronbach’s alpha if deleted, were also candidates for elimination. As recommended by Moore et al. (1991) and Green et al. (2000), checks were made before any item was deleted so that item elimination and improvement in reliability were not done at the expense of content validity for each measured construct. It should mention here that all poor quality items that were eliminated, except for perceived voluntariness item (item 29), were ‘negatively’ worded. This was consistent with Compeau’s et al. (2007) observation in which negatively worded items greatly affected reliability of scales due to respondents’ increased chances of misreading such items. Since three out of six items for perceived voluntariness were negatively worded, this seemed to be the most likely reason why it had one of the lowest reliabilities. After removing items from each scale, coefficient alpha was re-estimated until all poor quality items were eliminated and alpha was maximized. The last two columns in Table 1 show the items that were eliminated in each scale and the optimum alpha coefficient so far realized.

Results in Table 1 show that two constructs, compatibility with prior experience (CPE) and perceived voluntariness (VOL) exhibited very low estimates of internal consistency reliabilities (.477, and .594, respectively). These values were far below the acceptable minimum threshold, and a decision was made to exclude them from any subsequent multiple regression analyses where such variables were to be used as predictors. It should be noted that low reliability represents a great amount of measurement error in results and reduces the confidence in interpreting and utilizing findings. Since random errors affect both reliability and validity
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(Streiner, 2003), it can also be argued that any inference made on the basis of such findings would be invalid (Osterlind, 2006). On the other hand, including predictors with considerable measurement error leads to underestimation of the regression coefficients, thereby violating one of the assumptions of regression (Pedhazur, 1997). Regarding the effect of reliability in multiple regression, Osborne and Waters (2002) contended that including independent variables that have low reliabilities in the regression model may result in other variables sharing the error variance variables and the resulting accounted variance will be incorrect. In general, unreliable variables will result in erroneous findings and increased probability for type II errors in the case of unreliable variables, and type I errors for other variables (Osborne, et al., 2002).

Participants’ demographic and employment characteristics

In this section, findings on participants’ sex, age, level of education, and teaching experience will be described. In addition, the type of schools where they were teaching, their work load, and their teaching subjects and class sizes will be described. Lastly, findings on whether or not there was need for the TALULAR innovation, and whether or not they adopted and were using it for teaching will be presented.

Sex and age

Of the 269 usable responses, males accounted for 84% \( (n = 225) \) of the responses, and females comprised 16% of the responses \( (n = 44) \). Ninety six percent \( (n = 26) \) of these science teachers were school heads or principals. Respondents’ ages ranged from 20 years to over 60 years with a mean age range of 36-40. However, the majority (76.8%) of them were within the age bracket of 26-40 years (see Table 2 for sex and age distributions).

Level of education

Participants were asked to report the highest level of education attained. MSCE holders
accounted for 32.3% \((n = 87)\), 36.8% \((n = 99)\) held a diploma qualification, and 30.1% \((n = 80)\) had a bachelor’s degree. Of the remaining participants, 0.4% \((n = 1)\) had a Masters degree and another .4% \((n = 1)\) had a London-based O’ Level qualification, which is equivalent to MSCE in Malawi (see Table 2). Participants also indicated if they had an additional (higher) qualification than the ones specified in the survey instrument. Of the 87 who had an MSCE, two had a University Certificate in Sciences (UCS) offered under the Secondary School Teacher Improvement Program (SSTIP) at Mzuzu University. Of the 81 who held a Bachelor’s degree, three had a University Certificate in Education (UCE) offered by the University of Malawi (Chancellor College) to those with non-educational bachelor’s degrees to qualify them to teach at in secondary schools. In addition, one had a Post Graduate Diploma in Instructional Technology (IT), a distance education program offered by Mzuzu University that emanated from a UPIC project collaboratively run by Mzuzu University (Malawi) and Virginia Tech (USA). Overall, the majority of participants (67%) who had at least a diploma qualification had satisfactory credentials that qualified them to teach at secondary school level.

Teaching experience

Responses regarding number of years of teaching showed that their teaching experience ranged from zero to more than 20 years. The mean number of years of teaching experience was in the range of 7-10 years with a large proportion (64.5%) of participants clustered within the 11->20 years of experience (see Table 2). Of the 257 participants who responded to the item that asked for the length of time they had been teaching at their current school, 54.5%, 26.9%, 10.0%, and 1.6% indicated that they had been teaching at their current schools for 1-3 years, 4-6 years, 7-9 years, and 10-12 years, respectively. The rest (7.0%) had been at their present schools for
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less than a year. The overall mean teaching experience at the current school was 3.3 years ($SD = 2.35$).

**Distribution of teachers stratified by school type**

Of the 269 participants, 36% ($n = 97$) of them were teaching in Conventional Secondary Schools (CSSs) while 64% ($n = 172$) were teaching in Community Day Secondary Schools (CDSSs), (see Table 2). Secondary school science teachers with an MSCE certificate (equivalent to a high school diploma in the American education system) are considered unqualified or under-qualified. Of these under-qualified teachers, a majority of them ($98.8\%, n = 84$) were teaching in CDSSs and only $1.2\% (n = 1)$ were teaching in CSSs (see Table G1 in Appendix G).

**Distribution of teachers stratified by teaching subjects**

Regarding subjects that were being taught, there were the following scenarios: A teacher would be teaching (a) one subject to a single grade level with multiple streams, (b) one subject but at different grade levels, or, (c) different subjects at different grade levels. In general, teachers were either teaching a single subject or more than one subject to one or more grade levels at the same school. As shown in Table G2, those who indicated that they were teaching senior secondary school level (forms 3 and 4 or grades 11 and 12) Physical science, Biology and Agriculture were in proportions of $23.4\% (n = 63), 33.8\% (n = 91)$, and $24.9\% (n = 67)$, respectively. Those that reported teaching junior secondary school level (forms 1 and 2 or grades 9 and 10) Physical Science, Biology and Agriculture were in proportions of $32.7\% (n = 88), 39.4\% (n = 106)$ and $26.4\% (n = 71)$, respectively. The largest proportion of participants reported teaching junior level Biology ($n = 106$).
Table 2

*Participants’ demographic and employment characteristics.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>n</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>Male</td>
<td>225</td>
<td>83.6</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>44</td>
<td>16.4</td>
</tr>
<tr>
<td>Age (yrs)</td>
<td>20-25</td>
<td>20</td>
<td>7.5</td>
</tr>
<tr>
<td></td>
<td>26-30</td>
<td>30</td>
<td>11.2</td>
</tr>
<tr>
<td></td>
<td>31-35</td>
<td>33</td>
<td>12.3</td>
</tr>
<tr>
<td></td>
<td>36-40</td>
<td>85</td>
<td>31.7</td>
</tr>
<tr>
<td></td>
<td>41-45</td>
<td>58</td>
<td>21.6</td>
</tr>
<tr>
<td></td>
<td>46-50</td>
<td>25</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>51-55</td>
<td>11</td>
<td>4.1</td>
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<td></td>
<td>56-60</td>
<td>3</td>
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<td>&gt;60</td>
<td>3</td>
<td>1.1</td>
</tr>
<tr>
<td>Educational qualification</td>
<td>MSCE</td>
<td>87</td>
<td>32.3</td>
</tr>
<tr>
<td></td>
<td>Diploma</td>
<td>99</td>
<td>36.8</td>
</tr>
<tr>
<td></td>
<td>Bachelor’s</td>
<td>80</td>
<td>30.1</td>
</tr>
<tr>
<td></td>
<td>Masters</td>
<td>1</td>
<td>.4</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>1</td>
<td>.4</td>
</tr>
<tr>
<td>Teaching experience (yrs)</td>
<td>0-3</td>
<td>53</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
<td>4-6</td>
<td>8</td>
<td>3.0</td>
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<td></td>
<td>7-10</td>
<td>34</td>
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<tr>
<td></td>
<td>11-14</td>
<td>56</td>
<td>21.0</td>
</tr>
<tr>
<td></td>
<td>15-20</td>
<td>68</td>
<td>25.5</td>
</tr>
<tr>
<td></td>
<td>&gt;20</td>
<td>48</td>
<td>18.0</td>
</tr>
<tr>
<td>Type of school where teaching</td>
<td>CDSS</td>
<td>172</td>
<td>63.9</td>
</tr>
<tr>
<td></td>
<td>CSS</td>
<td>97</td>
<td>36.1</td>
</tr>
</tbody>
</table>

*Teaching load*

Teaching load in the context of secondary school education in Malawi is usually
expressed in terms of the number of periods, or in terms of the number of 40-45 minute lessons an instructor teaches per week. The ministry of education in Malawi recommends a minimum of 14 periods per week and a maximum of 21 periods per week as an acceptable teaching load for secondary school teachers (N.S. Msoka, personal communication, November 10, 2008). Due to the shortage of teachers and inequalities in teacher deployment among schools, it is not uncommon for teachers in some schools to have less than 14 periods per week or more than 21 periods per week. Two hundred and forty nine participants responded to the question that asked them to indicate the number of periods they teach per week. Data revealed that 73.1% \( (n = 182) \) had teaching loads below the required minimum of 14 periods per week. This finding seemed to be in contradiction with the general outcry that there is a critical shortage of teachers in public secondary schools. Those that had the recommended amount of teaching load accounted for 21.7% \( (n = 54) \), and only 5.2% \( (n = 13) \) were overloaded and were teaching more than the required maximum of 21 periods a week (see Table G3 under Appendix G). Of those with a recommended amount of teaching load, 13.3% were in CSSs and 8.4% were in CDSSs. A further analysis of data showed that a larger proportion (53.4%) of teachers teaching less than the required minimum number of periods (2-13 periods per week) were in CDSSs, and only 19.7% were in CSSs (see Table G4). While there were more teachers with lighter teaching loads in CDSSs than in CSSs, it should be noted that a greater proportion (about 50%) of CDSSs teachers had MSCE qualifications and were considered under-qualified (see Table G1).

**Student to textbook ratio**

Respondents were also asked to report the number of students enrolled in each subject they were teaching, and the number of recommended textbooks available. Using this data, student to textbook ratios were computed. Table G5 provides summary statistics on student
enrollments by subject, the reported number of textbooks available, and computed student to
textbook ratios. The overall student to textbook ratio was 7:1. This means that for every seven
students, there was one textbook available or seven students shared a single textbook.
Agriculture at both senior and junior level had the highest student/textbook ratio of 9:1, while
senior level Physical Science was reported to have the highest number of recommended
textbooks with the lowest student to textbook ratio of 4:1.

Student to teacher ratios

Student to teacher ratios were computed from the reported data on the total number of
science teachers who provided responses and their reported total enrollment numbers in all
subjects they were teaching (see Table G6). Relative to the number students, CSSs had fewer
numbers of teachers with a student to teacher ratio of 195:1 when compared to CDSSs, which
had a student to teacher ratio of 127:1. This observation was only true when all teachers,
irrespective of their qualifications, were considered. However, if only qualified teachers were
taken into account, the student to qualified teacher ratio in CDSSs would be 261:1, which is
much higher than that in CSSs (195:1). The overall student to teacher ratio for both CDSSs and
CSSs was 151:1. These ratios appear to be much higher than the ratio (40:1) targeted by the
ministry of education in order to improve the quality of secondary school education in Malawi
(MoESC, 2001). However, it is important to note that these ratios do not represent the number of
students per class, but rather represent the total number of science students for which one science
teacher was responsible for.

Need for TALULAR, Adoption and use

Teachers were asked to indicate whether there was a need for the TALULAR innovation
in teaching science subjects in public schools, and whether or not they had adopted TALULAR
and were using it in their teaching. Table G7 summarizes their responses to the questions.

*Need for TALULAR.* Out of the 267 participants who responded to the item about whether or not there was a need for TALULAR, 97.8% ($n = 261$) said there was need while 2.2% ($n = 6$) said there was no need for the innovation (see Table G7). The next question asked participants to explain their answers. Out of the 261 who responded yes, six did not provide any reason and four provided invalid responses that were not related to the question. Therefore, 251 participants who supported the innovation provided valid reasons. After grouping responses into main categories and emergent themes, 64% ($n = 160$) explained that TALULAR helped facilitate teaching and learning in that some concepts were taught and understood better when the innovation was utilized in the teaching and learning process. In addition, it helped arouse students’ interest and made teaching more relevant to their daily lives. Forty six percent ($n = 116$) explained that TALULAR was needed because their schools had a shortage of conventional or factory-made teaching and learning resources. According to respondents, locally available resources were less expensive to make or acquire, and were found within the vicinity of their local environment. Two participants (0.8%) indicated that TALULAR promoted creativity in learners, while only one (0.4%) explained that use of TALULAR encouraged learners to be resourceful.

For the six respondents who said there was no need for TALULAR, one gave an invalid response unrelated to the question, and there were five valid reasons. Of these, two indicated that not all resources in school could be improvised, two said the innovation was time-consuming, and one said teaching is not complete when using TALULAR. It is a legitimate argument that not all resources could be improvised. For instance, everyone would agree that there are no obvious alternatives for resources like a microscope, an oscilloscope, or chemicals, to mention
but a few. While this seemed to be one of the limitations of this innovation, users need to understand that improvisation is only but a subset of TALULAR and may not invalidate the usefulness of the innovation. The other reasons given against the innovation were related to the heavy teaching load, lack of knowledge and skills in using the innovation, individual attitude towards the innovation, and lack of commitment to using the innovation.

Adoption of TALULAR. Respondents were asked to state whether or not they have accepted or adopted TALULAR as a pedagogical innovation. Of the 266 participants who responded to this question, a higher proportion (98.5%, \( n = 262 \)) reported to have adopted it, and only 1.5% \( (n = 4) \) indicated that they did not adopt it (see Table G7). Evidently, the results showed that the innovation has been widely accepted as the best alternative to the shortage of teaching and learning resources in public secondary schools. This finding verified the study assumption that the innovation has been adopted by the targeted users.

Use of TALULAR. A total 258 participants responded to the item that asked them to state whether or not they use TALULAR in teaching. Of these, the majority (93.4%, \( n = 241 \)) indicated that they were using the innovation in teaching while 6.6% \( (n =17) \) were not (see Table G7). Again, these results show that TALULAR was being widely used by science teachers in the teaching and learning process.

Results by research question

The following section presents a summary of results in relations to each research question. The results for each research question are discussed in chapter 5.

Research Question One

What is the relationship between perceived attributes of using TALULAR innovation and the level of implementation?
Perceptions of Innovations as Predictors of TALULAR Implementation

A composite score for each perception of innovation construct was computed by averaging scores for all remaining items measuring the same construct after elimination of the poor ones. Table H1 in Appendix H provides the means and standard deviations of perceived attributes of using TALULAR and the implementation scores. Inter-correlations among PCIs are also shown in Table H2. The Pearson Product-Moment Correlation Coefficient ($r$) was used to determine if there were any significant correlations between each of the perceived attributes of TALULAR innovation and level of implementation. Table 3 shows the bivariate correlations between each perceived characteristic of innovation (PCIs) and level of implementation.

Summary of results

Results in Table 3 revealed significant bivariate positive correlations between level of implementation and: (a) perceived relative advantage, $r(263) = .280, p < .01$, (b) compatibility with prior experience, $r(263) = .166, p < .01$, (c) ease of use, $r(263) = .135, p < .05$, (d) others’ use, $r(263) = .233, p < .01$, (e) communicability, $r(263) = .200, p < .01$, (f) measurability, $r(263) = .189, p < .01$, (g) trailability, $r(263) = .202, p < .01$, and (h) image, $r(263) = .265, p < .01$. This means that teachers’ favorable perceptions of using the innovation were associated with increased levels of implementation.

However, there was a statistically significant negative relationship between perceived voluntariness of using TALULAR and implementation, $r(263) = -.283, p < .01$. This meant that teachers who perceived the innovation to be more voluntary implemented it at lower levels. While there was a positive relationship between compatibility with values and implementation, the relationship was not statistically significant.

Research Question Two

Do the attributes of innovations have any utility value in predicting the implementation of
Simultaneous regression was used to determine the extent to which the perceived characteristics of innovations collectively and separately contributed to the prediction of the level of TALULAR implementation. Since the relationship between compatibility with values (CWV) and implementation was statistically non-significant, it was excluded in the regression model.

Table 3

*Bivariate correlations between each PCI and implementation (n = 265)*

<table>
<thead>
<tr>
<th>PCI</th>
<th>Correlation (r) with implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Advantage (RAD)</td>
<td>.280**</td>
</tr>
<tr>
<td>Compatibility with Prior Experience (CPE)</td>
<td>.166**</td>
</tr>
<tr>
<td>Compatibility With Values (CWV)</td>
<td>.091</td>
</tr>
<tr>
<td>Ease of Use (EOU)</td>
<td>.135*</td>
</tr>
<tr>
<td>Others' Use (OOU)</td>
<td>.233**</td>
</tr>
<tr>
<td>Communicability (OCM)</td>
<td>.200**</td>
</tr>
<tr>
<td>Measurability (OMS)</td>
<td>.189**</td>
</tr>
<tr>
<td>Trialability (TRI)</td>
<td>.202**</td>
</tr>
<tr>
<td>Voluntariness (VOL)</td>
<td>-.283**</td>
</tr>
<tr>
<td>Image (IMA)</td>
<td>.265**</td>
</tr>
</tbody>
</table>

*Note.** Correlation (r) is significant at the 0.01 (2-tailed); * Correlation (r) is significant at the 0.05 (2-tailed); df = n-2 = 263

To check whether or not it accounted for a significant amount of variance in implementation, implementation was regressed on CWV and the overall regression was insignificant. At this
point, any possibility of mediation with the other criterion variables was ruled out. Therefore, for this analysis, only seven predictors, which had significant correlations with the criterion variable and also had adequate reliability estimates of .70 and above, were included in the regression analysis.

**Summary of results**

Table 4 shows the simultaneous regression analysis results when implementation was regressed on the seven predictors: RAD, EOU, OOU, OCM, OMS, TRI, and IMA. The overall regression equation with all seven predictors was significant ($R^2 = .127$, Adjusted $R^2 = .104$), $F(7, 257) = 5.359$, $p < .01$. These results show that collectively, the predictors account for 12.7% of variance in implementation of TALULAR. Examination of the tests of significance for the regression coefficients showed that, independently, only three predictors (perceived relative advantage, ease of use, and others’ use) can significantly predict the level of implementation among secondary school science teachers in Malawi (see Table 4). Controlling for other variables, perceived relative advantage was the strongest predictor of the level of TALULAR implementation; a unit increase in the perceived relative advantage was related to .490 (or .248 standard deviation) unit increases in the predicted level of implementation.

Based on the parameter estimates from Table 4, the following is the prediction equation:

$$L'I' = .082 + .490 (RAD) -.339(EOU) + .239(OOU) + .042(OCM) + .008(OMS) + .072(TRI) + .172(IMA)$$

(1a)

where $L'I'$ = predicted level of implementation.

The predicted level of implementation for a respondent who perceives the innovation most favorably (strongly agrees and scores a 5) would be...
Perceptions of Innovations as Predictors of TALULAR Implementation

LI’ = .082 + .490(5) - .339(5) + .239(5) + .042(5) + .008(5) + .072(5) + .172(5) = .2642 \approx 3.0, which is roughly a moderate level of predicted implementation.

Regression equation 1a was revised by deleting variables not contributing significantly to the variance accounted for by the overall regression model. Based on Pedhazur’s (1997) and Osborne’s (2000) recommendation, variables were deleted one at a time, beginning with ones with the lowest t values while re-examining the effects of deletion on the increments and significance of the b’s for the remaining variables. When measurability, communicability, and trialability were excluded in this order, the perceived image of using TALULAR became significant (see Table II). Equation 1b below is the revised version of the prediction equation 1a. This equation, which consisted of predictors only contributing significantly in accounting for variance in implementation, accounted for 12.6% of the variability in the level of implementation of TALULAR \((R^2 = .126, \text{Adjusted } R^2 = .112, F(4, 260) = 9.346, p < .01)\).

\[
\text{(LI')} = .181 + .502(\text{RAD}) - .298(\text{EOU}) + .260(\text{OOU}) + .194(\text{IMA}) \quad (1b)
\]

Similarly, using equation 1b, the predicted level of implementation for a respondent who perceives the innovation most favorably would be

LI’ = .181 + .502(5) - .298(5) + .260(5) + .194(5) = 3.501 \approx 4.0, which is a high predicted level of implementation.

It should be noted here that if compatibility with values, which was not significantly related to the criterion, was included in the initial model, the overall model would also have significantly explained 13.3% of variance in implementation, adding an additional .6% \((R^2 = .133, \text{adjusted } R^2 = .106, p < .01)\). However, its independent contribution to the explained variance was not significant, and it would still have been eliminated in the revised model 1b.
Therefore, the results of the revised model 1b would have been the same even if CWV were to be included in running model 1a.

**Research Question Three**

*What are the relationships among teacher demographic and employment variables (such as gender, level of education, teaching experience, type of school, and training) and the implementation of TALULAR?*

Table 4

*Summary simultaneous regression results for the 7 predictors of implementation*

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>.082</td>
<td>.578</td>
<td>.142</td>
<td>.887</td>
<td></td>
</tr>
<tr>
<td>Relative Advantage</td>
<td>.490**</td>
<td>.169</td>
<td>.248</td>
<td>2.895</td>
<td>.004</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>-.339*</td>
<td>.158</td>
<td>-.190</td>
<td>-2.140</td>
<td>.033</td>
</tr>
<tr>
<td>Others' Use</td>
<td>.239*</td>
<td>.112</td>
<td>.143</td>
<td>2.124</td>
<td>.035</td>
</tr>
<tr>
<td>Communicability</td>
<td>.042</td>
<td>.164</td>
<td>.022</td>
<td>.256</td>
<td>.798</td>
</tr>
<tr>
<td>Measurability</td>
<td>.008</td>
<td>.173</td>
<td>.004</td>
<td>.046</td>
<td>.963</td>
</tr>
<tr>
<td>Trialability</td>
<td>.072</td>
<td>.135</td>
<td>.043</td>
<td>.535</td>
<td>.593</td>
</tr>
<tr>
<td>Image</td>
<td>.172</td>
<td>.095</td>
<td>.137</td>
<td>1.820</td>
<td>.070</td>
</tr>
</tbody>
</table>

Note. \( R^2 = .127 \), Adjusted \( R^2 = .104 \). * \( p < .05 \), ** \( p < .01 \)

Pearson correlations (two-tailed) were used to investigate the relationships between each of the demographic and employment variables and the level of implementation of TALULAR. Two-tailed significance was used to evaluate statistical significance because there was no hypothesized direction of the relationships.
Summary of results

Table 5 presents a summary of bivariate correlations between each of the demographic and employment characteristics of respondents and the level of implementation.

Table 5

<table>
<thead>
<tr>
<th>Variable</th>
<th>Correlation ($r$) with implementation</th>
<th>$n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>.066</td>
<td>265</td>
</tr>
<tr>
<td>Level of education</td>
<td>-.141*</td>
<td>265</td>
</tr>
<tr>
<td>Teaching experience</td>
<td>.068</td>
<td>263</td>
</tr>
<tr>
<td>School type</td>
<td>-.123*</td>
<td>265</td>
</tr>
<tr>
<td>Training attendance</td>
<td>.146*</td>
<td>259</td>
</tr>
<tr>
<td>Length of training</td>
<td>.087</td>
<td>128</td>
</tr>
</tbody>
</table>

Note. * Correlation ($r$) is significant at the 0.05 (2-tailed). $df = n-2$

Evidently, significant correlations were found between the level of implementation and (a) the level of education, $r(263) = -.141, p < .05$, (b) type of school, $r(263) = -.123, p < .05$, and (c) innovation training attendance, $r(257) = .146, p < .05$. The rest of the associations were statistically not significant. In general, the results show that participants who: (i) had higher educational qualifications, (ii) were teaching in CSSs, and (iii) did not attend training, implemented TALULAR at lower levels than those who had lower qualifications, were in CDSSs, and had attended training for the innovation. A discussion of these findings is found in Chapter 5.
Perceptions of Innovations as Predictors of TALULAR Implementation

Research Question Four

Controlling for teacher demographic and employment variables, can the perceptions of innovations together significantly predict the implementation of TALULAR?

From a review of literature, the researcher suspected that the targeted organizational members’ perceptions about using an innovation were, to some extent, influenced by their demographic and employment characteristics (see chapter 2). For instance, if one is highly educated (having accrued adequate knowledge and skills), he or she may perceive using an innovation to be less complex. On the other hand, this knowledge and skill may help him or her evaluate the relevance of the innovation, and after finding it less suited to the need, he or she could develop negative attitudes toward using it, and may never make a commitment to using it on a routine basis. Using hierarchical regression analysis, the predictive value of these perceptions of using innovations was investigated after controlling for the demographic and employment variables. Inter-correlations among perceptions of innovations and demographic and employment variables are shown in Table I2. From the bivariate correlation results in Table 5 above, the level of education, school type, and training attendance, which were significantly related to the level of implementation, were controlled for.

Summary of results

The results of a hierarchical (block-wise) regression analysis are summarized and presented in Table 6. Demographic and employment (dummy coded) variables significantly accounted for 4.5% of variance in the implementation of TALULAR, \( R^2 = .045, F(4,254) = 2.969, p < .05 \). After controlling for these variables, perceptions of using TALULAR innovation significantly accounted for 9.0% of variance in implementation, \( \Delta R^2 = .090, F(7,247) = 3.649, p < .01 \). Model 1 and model 2 together significantly accounted for 13.4% of variance in
implementation, $R^2 = .134$, $F(11, 247) = 3.480$, $p < .01$. Controlling for other variables, the perceived relative advantage was the strongest predictor of the level of TALULAR implementation; a unit increase in the perceived relative advantage was related to .231 standard deviation unit increases in the predicted level of implementation. In summary, the perceptions of innovations significantly accounted for variance in the level of implementation, and can collectively predict implementation levels of TALULAR after demographic and employment variables have been controlled for.

The prediction equation after controlling for demographic and employment variables is:

\[
LI' = .205 + .453(RAD) - .327(EOU) + .241(OOU) + .033(OCM) + .004(OMS) \\
+ .065(TRI) + .151(IMA)
\]  

(2a)

Using equation 2a, the predicted level of implementation for a respondent who perceives the innovation most favorably (strongly agrees and scores a 5) would be: $LI' = .205 + .453(5) - .327(EOU) + .241(5) + .033(OCM) + .004(5) + .065(5) + .151(5) \approx 3.4$, which is a moderate predicted level of implementation.

The prediction model shown in equation 2a was revised to include only predictors that substantially contributed to the prediction power of the equation. Starting with the predictor with the lowest $t$ value, predictors were removed from the regression model one at a time and changes in the significance of $b$’s were noted until all the $b$’s became significant. The revised prediction equation is shown in equation 2b.

\[
LI' = .244 + .544(RAD) - .258(EOU) + .282(OOU)
\]  

(2b)

Similarly, using equation 2b, the predicted level of implementation for a respondent who perceives the innovation most favorably (strongly agrees and scores 5) would be

$LI' = .244 + .544(RAD) - .258(EOU) + .282(OOU) = .244 + 2.720 - 1.290 + 1.410 \approx 3.1$, which is
Perceptions of Innovations as Predictors of TALULAR Implementation

Table 6

*Hierarchical regression results for demographic/employment variables and PCIs on implementation*

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>2.295</td>
<td>.141</td>
<td></td>
</tr>
<tr>
<td>Level of education: D1</td>
<td>.215</td>
<td>.190</td>
<td>.097</td>
</tr>
<tr>
<td>: D2</td>
<td>.187</td>
<td>.161</td>
<td>.086</td>
</tr>
<tr>
<td>School type</td>
<td>.200</td>
<td>.158</td>
<td>.092</td>
</tr>
<tr>
<td>Training attendance</td>
<td>.284*</td>
<td>.129</td>
<td>.136</td>
</tr>
<tr>
<td><strong>Step 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>.205</td>
<td>.591</td>
<td></td>
</tr>
<tr>
<td>Relative advantage</td>
<td>.453*</td>
<td>.174</td>
<td>.231</td>
</tr>
<tr>
<td>Ease of use</td>
<td>-.327*</td>
<td>.164</td>
<td>-.183</td>
</tr>
<tr>
<td>Others’ use</td>
<td>.241*</td>
<td>.115</td>
<td>.145</td>
</tr>
<tr>
<td>Communicability</td>
<td>.033</td>
<td>.170</td>
<td>.018</td>
</tr>
<tr>
<td>Measurability</td>
<td>.004</td>
<td>.179</td>
<td>.002</td>
</tr>
<tr>
<td>Trialability</td>
<td>.065</td>
<td>.139</td>
<td>.038</td>
</tr>
<tr>
<td>Image</td>
<td>.151</td>
<td>.100</td>
<td>.120</td>
</tr>
</tbody>
</table>

*Note. $R^2 = .045$ for step 1 ($p < .05$); $F(4, 254) = 2.969$. $\Delta R^2 = .090$ for step 2 ($p < .01$), $F(7, 247) = 3.649$. *

* $B$ is significant at $p = .05$. Total $R^2$ for step 1 and 2 = .134, adjusted $R^2 = .096$
a moderate predicted level of implementation. In this revised prediction equation, perceptions of innovations also significantly accounted for 7.7% (a reduction of 1.3% from model 2a) after controlling for demographic and employment variables, $\Delta R^2 = .077$, $\Delta F (3, 251) = 7.342, p < .01$.

It should be noted here that if all demographic and employment variables were controlled for (including those which did not significantly contribute to the prediction power), the adjusted $R^2$ (which corrects for the positive bias in $R^2$ due to changes in the number of predictors) for step 1 that comprised demographic and employment variables becomes essentially zero, and the variance in implementation accounted for by demographic and employment variables becomes statistically insignificant (adjusted $R^2 = -.007$, $R^2 = .098$, $p > .05$). On the other hand, if compatibility with values, which was not significantly related to implementation was included, the PCIs collectively accounted for 17.3% of variance in implementation ($\Delta R^2$ for model 2 = .173, $p < .01$). In this case, when considered independently, none of the predictors (except perceived compatibility with values, $B = -.402$, $SEB = .190$, $p < .05$) in step 2 significantly accounted for variance in the level of implementation. However, the collective model (including demographic and employment and perception of innovation variables) accounted for a significant and apparently the greatest amount of variance (27.1%) in the level of implementation than any other model ($R^2 = .271$, adjusted $R^2 = .124, F(21, 104) = 1.838, p < .05$).

Research Question Five

*What is the most parsimonious model that could be used to optimize the prediction of the level of TALULAR implementation when perceived characteristics and demographic and employment variables are considered together?*

To answer this question, stepwise regression analysis was conducted. Eight perceptions of innovation constructs, which had an acceptable internal consistency reliability of at least .70
Perceptions of Innovations as Predictors of TALULAR Implementation

(see Table 1), and all six demographic and employment variables were included in the stepwise regression analysis. Since the goal of stepwise regression analysis is to optimize prediction, no variable pre-selection based on statistical characteristics was done. This was to allow the stepwise selection procedure to select variables that would contribute substantially to the prediction power of the equation. The following were the variables included in this analysis: relative advantage, compatibility with values, ease of use, others’ use, communicability, measurability, trialability, image, school type, training attendance, level of education, teaching experience, and length of training, and gender. Dummy coded variables for demographic and employment categorical variables were used.

Table 7

Stepwise regression results for PCIs and demographic and employment variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-.508</td>
<td>.913</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative advantage</td>
<td>.786**</td>
<td>.212</td>
<td>.316</td>
<td>.000</td>
</tr>
<tr>
<td><strong>Model 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-.978</td>
<td>.921</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative advantage</td>
<td>.635**</td>
<td>.219</td>
<td>.255</td>
<td>.004</td>
</tr>
<tr>
<td>Others’ use</td>
<td>.317*</td>
<td>.139</td>
<td>.201</td>
<td>.024</td>
</tr>
</tbody>
</table>

Note. $R^2 = .100$ for model 1 ($p < .01$) and adjusted $R^2 = .093$; $\Delta R^2 = .037$ for model 2 ($p < .05$). Total $R^2$ for 2 models = .136 and adjusted $R^2 = .122$ ($p < .01$). *B is significant at $p = .05$, **B is significant at $p = .01$. 

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Summary of results

The results of a stepwise regression analysis are shown in Table 7 above. Stepwise regression analysis only selected two variables (represented in two models) that contributed substantially (both collectively and independently) to the prediction power of the regression equation beginning with the most important predictor, perceived relative advantage, which constituted model 1. Being the strongest predictor, relative advantage significantly accounted for 10.0% of the variance in implementation ($R^2 = .100$, adjusted $R^2 = .093$, $F(1, 124) = 13.769, p < .01$). The change in the amount of variance (3.7%) in implementation accounted for by the second most important predictor (others’ use), yielding model 2, was also significant ($\Delta R^2 = .037$, $\Delta F(1, 123) = 5.207, p < .05$). In total, the two predictors (RAD and OOU) significantly accounted for nearly 14% of the total variance in the level of implementation of TALULAR, $R^2 = .136$, adjusted $R^2 = .122$, $F(2,123) = 9.722, p < .01$ (see Table 7 above).

From these parameter estimates, the most parsimonious prediction equation becomes:

$$LI' = -.978 + .635(RAD) + .317(OOU)$$

(3)

Where $LI'$ = predicted level of implementation.

Using equation 3, the predicted level of implementation for a respondent who perceives both relative advantage and others’ use most favorably and scores a 5 (strongly agrees) would be

$$LI' = -.978 + .635(5) + .317(5) = -.978 + 3.175 + 1.585 = 3.78 \sim 4.0,$$

which is a high predicted level of implementation.

It should also be pointed out that if only perceptions of innovations (with internal consistency reliabilities of .70 or higher) and demographic and employment variables, which had significant relationships with the level of implementation were included in the stepwise regression model, perceived relative advantage, others’ use, image, and ease of became the most
important variables contributing significantly to the prediction power of the model. These variables collectively explained nearly 13% of variance in the level of implementation \( R^2 = .128 \), adjusted \( R^2 = .114 \), \( F(4,254) = 9.299, p < .01 \), with relative advantage explaining the largest proportion (about 8%) of variance \( R^2 = .079 \), adjusted \( R^2 = .075 \), \( F(1,257) = 21.921, p < .01 \).

Research Question Six

Are there differences in the perceptions of innovations and the level of implementation by gender, level of education, teaching experience, school type, training attendance, and length of training?

Question six was analyzed by breaking it down into two parts: part 1, where implementation was the dependent variable, and part 2, where each perceived characteristic of using TALULAR innovation was the dependent variable. Demographic and employment variables represented levels or groups.

Summary of results: Part 1, question six

Gender, school type, and training attendance. An independent-samples \( t \) test was conducted to investigate if there were significant differences in levels of implementation based on respondents’ gender, school type and training attendance. Results of this analysis are presented in Table 8. After running the independent-samples \( t \) tests, the underlying assumption that population variance for the two groups were equal was verified by looking at the results of Levene’s test. In all cases, the Levene’s test for homogeneity of variances was not statistically significant \( (p > .05) \), therefore, equal variances were assumed (see Table J1).

Results show that there was no significant difference in the level of TALULAR implementation between male \((M = 2.66, SD = 1.031)\) and female \((M = 2.84, SD = 1.098)\) respondents, \( t(263) = -1.074, p > .05 \). However, there were significant differences in the level of
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TALULAR implementation between school type, that is, between respondents in CDSSs \( (M = 2.78, SD = 1.063) \) and CSSs \( (M = 2.52, SD = .988) \), \( t(263) = 2.007, p < .05 \), and between respondents who had ever attended TALULAR training \( (M = 2.86, SD = 1.029) \) and those who did not \( (M = 2.55, SD = 1.043) \), \( t(257) = 2.369, p < .05 \). In summary, while the results did not show that the level of implementation was dependent on gender, participants in CDSSs and those who attended TALULAR training reported significantly higher levels of TALULAR implementation than those in CSSs and those who had never attended training.

Table 8

*Independent-samples t test comparing gender, school type & training attendance.*

<table>
<thead>
<tr>
<th>Grouping variable</th>
<th>Groups</th>
<th>( n )</th>
<th>( M )</th>
<th>( SD )</th>
<th>( t )</th>
<th>( df )</th>
<th>Effect size ( (d) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender:</td>
<td>Male</td>
<td>221</td>
<td>2.66</td>
<td>1.031</td>
<td>-1.074</td>
<td>263</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>44</td>
<td>2.84</td>
<td>1.098</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School type:</td>
<td>CDSS</td>
<td>170</td>
<td>2.78</td>
<td>1.063</td>
<td>2.007*</td>
<td>263</td>
<td>.26</td>
</tr>
<tr>
<td></td>
<td>CSS</td>
<td>95</td>
<td>2.52</td>
<td>.988</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training attendance:</td>
<td>Attended</td>
<td>127</td>
<td>2.86</td>
<td>1.029</td>
<td>2.369*</td>
<td>257</td>
<td>.30</td>
</tr>
<tr>
<td></td>
<td>Not attended</td>
<td>132</td>
<td>2.55</td>
<td>1.043</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Dependent variable = Level of implementation; \( *p < .05 \) (2-tailed); \( d = \frac{t\sqrt{n_1n_2}}{n_1+n_2} \)

*Level of education, experience, and length of training.* The level of education was recoded into three categories from the initial six categories. The JCE category was eliminated because no participant had a JCE qualification, one respondent with a Masters qualification was grouped together with the bachelor’s category, and the only respondent in the ‘other’ category, who had a GCE, a London-based O’ Level equivalent to an MSCE qualification, was grouped
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with the MSCE category. Some of those who had an MSCE or a Bachelor’s qualification had additional and higher certifications, such as a University Certificate in Sciences (UCS) and University Certificate in Education (UCE), respectively. For these reasons, three categories with relatively similar numbers of respondents were used in the analysis. The three categories were as follows: (i) MSCE or equivalent & above ($n = 88$), (ii) Diploma ($n = 99$), and (iii) Bachelor’s & above ($n = 82$). However, these three categories will generally be referred to as MSCE, diploma, and bachelor’s in order not to distract readers and improve readability.

Teaching experience was also recoded into five categories from the initial six categories. To make the number of respondents comparatively similar, respondents in the 4-6 year ranges ($n = 8$) were combined with those in the 7-10 year range ($n = 34$). Likewise, for the length of training category, those in the 11-13 hour range ($n = 2$), 14-16 hour range ($n = 2$), and 17-19 hour range ($n = 4$) were combined together to form an 11-19 hour range category ($n = 8$).

A one-way ANOVA was conducted to investigate whether the level of implementation was different for different groups based on: (a) level of education (MSCE or equivalent & above: $M = 2.84$, $SD = 1.066$; diploma: $M = 2.73$, $SD = 1.005$; bachelor’s & above: $M = 2.47$, $SD = 1.038$), (b) teaching experience (0-3yrs: $M = 2.56$, $SD = .998$; 4-10 yrs: $M = 2.79$, $SD = 1.116$; 11-14: $M = 2.56$, $SD = .996$; 15-20: $M = 2.79$, $SD = 1.000$; >20yrs: $M = 2.79$, $SD = 1.129$), and (c) length of TALULAR training (0-1hr: $M = 2.93$, $SD = 1.141$; 2-4hrs: $M = 2.72$, $SD = 1.047$; 5-7hrs: $M = 2.61$, $SD = .916$; 8-10hrs: $M = 3.13$, $SD = .915$; 11-19hrs: $M = 3.38$, $SD = 1.302$; >20hrs: $M = 2.89$, $SD = .974$). Results for Levene’s test for homogeneity (equality) of variance assumption of ANOVA are summarized in Table J2 under Appendix J. Since Levene’s test in all three cases was not significant ($p > .05$), the homogeneity assumption was met and, therefore, equal variances among groups were assumed.
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As shown in Table 9, ANOVA results showed no significant differences in implementation in regard to respondents’ level of education, $F(2,262) = 2.822, p > .05$; teaching experience, $F(4,258) = .758, p > .05$; or length of training, $F(5,122) = 1.018, p > .05$. Therefore, the level of TALULAR implementation among secondary school science teachers in the Northern region of Malawi did not differ based on their level of education, teaching experience, or the length of TALULAR training for those who had ever attended one.

Table 9

*Summary ANOVA results comparing level of education, experience and length of training.*

<table>
<thead>
<tr>
<th>Variable</th>
<th>SS</th>
<th>MS</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of education</td>
<td>6.053</td>
<td>3.026</td>
<td>2</td>
<td>2.822</td>
<td>.061</td>
</tr>
<tr>
<td>Teaching experience</td>
<td>3.293</td>
<td>.823</td>
<td>4</td>
<td>.758</td>
<td>.554</td>
</tr>
<tr>
<td>Length of training</td>
<td>5.372</td>
<td>1.074</td>
<td>5</td>
<td>1.018</td>
<td>.410</td>
</tr>
</tbody>
</table>

*Note.* Dependent variable = Level of implementation; All $p$s > .05

*Summary of results: Part 2, question six*

*Gender, school type, and training.* An independent-samples $t$ test (2-tailed) was conducted to investigate if there were any significant differences in perceptions of TALULAR innovation based on respondents’ gender, school type, and training attendance. Summary results are shown in Table K1 in Appendix K. In all cases (except for a few comparisons between perceptions and training attendance), equal variances were assumed as Levene’s statistic was not statistically significant. In view of the nature of results in Table K1, single statistics for each comparison (e.g., $t$, $df$ and $p$) will not be reported. Instead, emphasis will be on reporting whether or not results were statistically significant and the effect sizes.
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In terms of gender, an independent-sample $t$ test revealed that male and female respondents did not differ significantly on their perceptions regarding the use of TALULAR innovation.

Regarding school type, significant differences in perceptions of using TALULAR innovation were found between teachers in CDSSs and those in CSSs. Teachers in CDSSs perceived using TALULAR innovation to be significantly (a) more advantageous, (b) more compatible with both their prior experiences and values, (c) more observable in terms of others’ use, (d) more simple to use, (e) more trialable, and (f) less voluntary than their counterparts in CSSs. However, no significant differences were found between teachers in CDSSs and CSSs in their perceived measurability or communicability of the results of using the innovation. The effect sizes in all these cases are also shown in Table K1. Effect sizes where there were significant differences were generally small.

In regard to differences in perceptions of using TALULAR based on training attendance, except for perceived voluntariness, teachers who had attended training had significantly more favorable perceptions of using the innovation than those who did not. On the other hand, those who had ever attended training ($M = 2.106, SD = .589$) perceived the use of the innovation to be significantly more mandatory or less voluntary than those who did not ($M = 2.341, SD = .607$), $t(261) = -3.187, p < .01$ (see Table K1). Except for differences in perceived image, effect sizes (where there were significant differences in perceptions in terms of school type) as measured by Cohen’s $d$, were small. On the other hand, medium effect sizes in regard to perceived relative advantage, compatibility with prior experience, compatibility with values, communicability, trialability, and image were found between those who had attended training and those who did not (see Table K1)
Perceptions of Innovations as Predictors of TALULAR Implementation

Level of education, experience, and length of training. A one-way ANOVA was conducted to investigate whether the level of implementation was different for different groups based on level of education, teaching experience, and length of TALULAR training. Results of ANOVA are presented in Table L1 in Appendix L. For most comparisons, results for Levene’s test for homogeneity (equality) of variance, a key assumption of ANOVA, were not significant and equal variances were thus assumed. However, in a few comparisons, namely, the comparison of perceived ease of use (EOU), communicability (OCM), measurability (OMS), voluntariness (VOL) with respect to the level of education, and perceived voluntariness in relation to length of training, the assumption of homogeneity of variances were not met (see Table L1). It should be noted, however, that failure of homoscedasticity, also called homogeneity when data is grouped, does not invalidate the analysis rather than weaken it (Tabachnick & Fidell, 2007). ANOVA is considered to be very robust to the assumptions of normality and homogeneity in the face of large and comparatively equal sample sizes, and practically, these assumptions can be violated with minor effects (Caladari, Cobb, Minium & Clarke, 2004; Garson, 2008; Howell, 2007). Tabachnick et al. (2007) and Howell (2007) observed that violations of the homogeneity test are acceptable in cases of large and relatively equal sample sizes (when the ratio of the largest to the smallest group variance does not exceed 4:1) without noticeable or unacceptable rises in type I or type II error rates. One general rule of thumb provided by Caladarci, et al. (2004) is that when provided the ratio of the largest to the smallest group size does not exceed 1.5, unequal variances in ANOVA are acceptable.

As a result of the foregoing discussion, it was concluded that departures from the homogeneity assumption in these few cases were tolerable and did not invalidate findings, especially in the comparison of perceptions in relation to respondents’ level of education. In this
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study, samples were relatively large and groups sizes for MSCE or equivalent and above \( (n = 88) \), diploma \( (n = 99) \), and bachelor’s and above \( (n = 82) \) were not markedly different. The ratio of the largest to the smallest group variance did not exceed 4 nor did the largest to the smallest group sample size exceed 1.5. Additionally, in all cases, ANOVA results were considered valid because the population distributions were relatively symmetric and similar in shape (negatively skewed for level of education and positively skewed for length of training), and the largest variance was not more than four times the smaller one (see Howell, 2007).

ANOVA results are summarized in Table L1 under Appendix L. Except for perceived compatibility with values, there were significant differences in all perceptions of using TALULAR innovation in relation to respondents’ level of education. The Turkey’s HSD (honest significant difference) test revealed that respondents who had a bachelor’s degree rated the perceptions of using TALULAR significantly lower than those who had either a diploma or an MSCE qualification (see a summary of pairwise comparisons in Table L2). Except for the perception of voluntariness where diploma holders \( (M = 2.185, SD = .580) \) perceived TALULAR to be significantly more voluntary than MSCE holders \( (M = 1.977, SD = .454, p < .05) \), no significant differences in all other perceptions were found between respondents holding these qualifications.

Statistically significant differences in the perceptions of relative advantage, voluntariness, and image were found with respect to teaching experience. Post hoc analysis (see Table L2) showed the following significant pairwise comparisons: (a) those with 0-3 years of experience \( (M = 3.910, SD = .501) \) had significantly lower perceptions of relative advantage than those with 4-10 years of experience \( (M = 4.246, SD = .521) \) and 15-20 years of experience \( (M = 4.233, SD = .454) \), (b) those with 0-3 years of experience \( (M = 2.597, SD = .674) \) significantly perceived
the innovation to be more voluntary than those with 4-10 years of experience ($M = 2.130, SD = .622$), 11-14 years of experience ($M = 2.165, SD = .560$), 15-20 years of experience ($M = 2.123, SD = .568$), and those with more than 20 years of experience ($M = 2.108, SD = .479$), (c) those with 0-3 years of experience ($M = 3.132, SD = .752$) perceived the innovation to enhance their image significantly less than those with 15-20 years of teaching experience ($M = 3.568, SD = .802$).

In general, the results showed that the less experienced science teachers with 0-3 years of experience tended to rate the perceptions of using the innovation significantly lower than the more experienced teachers. No significant differences in perceptions of TALULAR were found between those with 4-10 years of experience, 11-14 years of experience, 15-20 years of experience, or more than 20 years experience. In all cases, there were no significant differences in perceptions of using TALULAR innovation based on the length of training.

It should be noted that the results of Kruskal-Wallis test, a nonparametric equivalent of ANOVA, yielded exactly identical results in cases where the ANOVA assumption of homogeneity of variances was not met. In addition, the Dunnett’s T3 and Games-Howell post hoc test, which do not assume equal variances, also yielded identical findings, that is, identified the same significant pairwise mean differences. These types of post hoc tests were done to assess the validity of findings. In cases where variances are not equal, Green et al. (2000) recommended using pos hoc analyses available in SPSS that do not assume equality of variance. Since results were identical, information from these additional tests added to the validity of findings.
Research Question Seven

Are there differences in teachers’ perceived characteristics of using TALULAR depending on the frequency of use?

A one-way ANOVA was conducted to determine whether or not the perceived characteristics of using TALULAR were different for different groups depending on the frequency with which they used the innovation. The independent variable, the level of implementation (measured by the frequency of use), had five levels: (i) do not use at all \( (n = 9) \), (ii) 1-5 times in a week \( (n = 145) \), (iii) 6-10 times in a week \( (n = 57) \), (iv) 11-15 times a week \( (n = 28) \), and (5) more than 15 times a week \( (n = 26) \). The dependent variables were each of the perceived characteristics of using the innovation. In all cases, except for perceived ease of use, the key assumption of ANOVA (the homogeneity of variances) as determined by Levene’s test was met. Considering that sample sizes for groups were markedly unequal, even though the largest to smallest variance ratio did not exceed 4 (see preceding discussion on violations to the homogeneity assumption under research question six), violations for the homogeneity assumption, in this case, were considered moderate. As a correction to the violation of homogeneity of variance, Tabacknic et al.(2007) recommended using either transformed or untransformed scores but employing a more stringent level of significance, such as using \( \alpha = .01 \) for the latter option in case of severe violations. In this study, therefore, the significance level for perceived ease of use in relation to frequency of use was evaluated at .01 for both the F test and the post hoc tests.

Summary of results

ANOVA results are summarized in Table M1 in Appendix M. Except for perception of compatibility with values (where respondents’ perceptions did not differ significantly based on
frequency of innovation usage), ANOVA found significant differences in the perceived characteristics of using TALULAR in relation to the frequency of use. Tukey’s multiple comparison tests (see Table M2 in Appendix M) showed that respondents who:

(i) did not use the innovation at all \((M = 3.533, SD = .828)\) rated the perceived relative advantage (RA) of using TALULAR significantly lower than those who used it 1-5 times a week \((M = 4.036, SD = .535)\), 6-10 times a week \((M = 4.356, SD = .354)\), 11-15 times a week \((M = 4.244, SD = .382)\), and more than 15 times a week \((M = 4.357, SD = .102)\).

(ii) did not use the innovation at all \((M = 3.278, SD = .775)\) rated the perceived observability in terms of communicability (OCM) of using TALULAR significantly lower than those who used it 1-5 times a week \((M = 3.839, SD = .536)\), 6-10 times a week \((M = 4.159, SD = .371)\), 11-15 times a week \((M = 3.991, SD = .563)\), and more than 15 times a week \((M = 4.019, SD = .667)\).

(iii) did not use the innovation at all \((M = 3.111, SD = .807)\) rated it to be significantly more voluntary (VOL) than those who used it 1-5 times a week \((M = 2.319, SD = .554)\), 6-10 times a week \((M = 1.983, SD = .491)\), 11-15 times a week \((M = 2.150, SD = .636)\), and more than 15 times a week \((M = 1.939, SD = .585)\).

(iv) did not use the innovation at all \((M = 2.467, SD = .849)\) rated it to have significantly less perceived image (IMA) than those who used it 1-5 times a week \((M = 3.266, SD = .814)\), 6-10 times a week \((M = 3.718, SD = .687)\), 11-15 times a week \((M = 3.682, SD = .767)\), and more than 15 times a week \((M = 3.683, SD = .851)\).
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(v) did not use the innovation at all \((M = 2.982, SD = .412)\) perceived it to have significantly less perceived compatibility with their prior experience (CPE) than those who used it 6-10 times a week \((M = 3.687, SD = .520)\) and more than 15 times a week \((M = 3.686, SD = .641)\).

(vi) did not use the innovation at all \((M = 3.445, SD = .640)\) perceived it to have significantly less observability in terms of measurability than those who used it 6-10 times a week \((M = 4.051, SD = .415)\), 11-15 times a week \((M = 4.044, SD = .401)\), and more than 15 times a week \((M = 3.977, SD = .638)\).

Other results worth mentioning relate to significant differences in perceptions of TALULAR between respondents who used the innovation 1-5 times a week and those who used it 6-10 times a week and/or greater than 15 times a week. Tukey’s post hoc tests (see Table M2 in Appendix M) showed significant differences in perceived:

(i) Relative advantage (RA) between those who used the innovation 1-5 times a week \((M = 4.032, SD = .535)\) and those who used it 6-10 times a week \((M = 4.355, SD = .354)\) and more than 15 times a week \((M = 4.357, SD = .518)\).

(ii) Compatibility with prior experience (CPE) between those who used it 1-5 times a week \((M = 3.432, SD = .585)\) and those who used it 6-10 \((M = 3.687, SD = .520)\).

(iii) Ease of use (EOU) between those who used the innovation 1-5 times a week \((M = 3.710, SD = .584)\) and those used it 6-10 times a week \((M = 4.009, SD = .446)\).

(iv) Observability in terms of others’ use (OOU) between those who used it 1-5 times a week \((M = 3.338, SD = .612)\) and those who used it more than 15 times a week \((M = 3.765, SD = .741)\).

(v) Observability in terms of communicability (OCM) of results between those who used it
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1-5 times a week ($M = 3.839, SD = .536$) and those who used it 6-10 times a week ($M = 4.160, SD = .371$).

(vi) Observability in terms of measurability (OMS) of results between those who used it 1-5 times a week ($M = 3.840, SD = .450$) and those who used it 6-10 times a week ($M = 4.051, SD = .415$).

(vii) Trialability (TRI) between those who used it 1-5 times ($M = 3.366, SD = .611$) and those who used it 6-10 times a week ($M = 3.676, SD = .484$).

(viii) Voluntariness (VOL) between those who used it 1-5 times a week ($M = 2.319, SD = .554$) and those who used it 6-10 times a week ($M = 1.983, SD = .491$).

(ix) Image (IMA) between those who used it 1-5 times a week ($M = 3.266, SD = .814$) and those who used it 6-10 times a week ($M = 3.718, SD = .687$).

There were no statistically significant differences in perceptions of using TALULAR between teachers who used the innovation 6-10 times a week and those who either used it 11-15 or more than 15 times a week. After, evaluating the significance at the .01 level because of unequal variances, no statistically significant differences in the perceived ease of use between those who did not use the innovation at all ($M = 3.413, SD = .787$) and those who used it 6-10 times a week ($M = 4.009, SD = .446$) were found.

In summary, (a) science teachers who did not use TALULAR at all rated their perceptions of the innovation lower than those who at least used the innovation once a week. The only exception was in the perceived voluntariness where those who did not use it at all perceived the innovation to be significantly more voluntary than those who used it. (b) Those who used the innovation 1-5 times a week tended to rate the perceptions significantly less than those who used it more frequently, especially those who used it 6-10 and more than 15 times a week.
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times a week. The exception was in perceived voluntariness in which case those who used it
1-5 times considered TALULAR to be more voluntary than those who used it 6-10 times a
week. (c) There were no significant differences in perceptions of using the innovation
between teachers who used it 1-5 times a week and those who used it 11-15 times a week. (d)
There were no statistically significant differences between those who used the innovation 6-
10 times a week and those who either used it 11-15 times a week or more than 15 times a
week.

As can be seen from the ANOVA results in Table M1, in cases where there were
significant differences, effect sizes ranged from small to large with slightly more than three
quarters (78%) being medium effects. The effect size in perceived image in relation to
frequency of TALULAR use was large.

It should be noted that results of the Kruskal-Wallis test, a nonparametric equivalent of
ANOVA, yielded exactly identical results for perceived ease of use in relation to frequency of
TALULAR use where variances were unequal. In addition, the Dunnett’s T3 and Games-Howell
post hoc tests, which do not assume equal variances, also yielded the identical findings, that is,
identified the same significant pairwise mean differences as Tukey’s HSD test). Since results
were identical, information from these additional tests added to the validity of findings regarding
the perceived characteristic of ease of use in relation to frequency of use.

Research Question Eight

To what extent has the TALULAR innovation been implemented by secondary school science
teachers in their instructional practices since the launch of the diffusion campaign around 1997?
Summary of results

Survey questions 3b and 6 as shown in Appendix D collected data that were used to answer this question. Results from Table G7 in Appendix G revealed that out of the total 269 respondents, 93.4% \((n = 241)\) indicated that they used TALULAR as a teaching tool while 6.6% \((n = 17)\) reported that they did not use the innovation. However, when they were asked to self-report the frequency with which they use the innovation per week, about 97% \((n = 256)\) reported that they used the innovation at least once a week (Table N1) and slightly more than 3% \((n = 9)\) indicated that they did not use it all. It should be noted that 97% represents a much more accurate proportion of those who reported using the innovation because there were very few \((n = 9)\) missing responses compared to the item that asked them whether or not they used TALULAR. Of those who used the innovation, 55% \((n = 145)\) used the innovation 1-5 times a week (low level of implementation), 22.3% \((n = 57)\) reported that they used it 6-10 times a week (moderate level of implementation), and 11% \((n = 28)\) reported using it 11-15 times a week (high level of implementation), and 10.2% \((n = 26)\) reported that they used it more than 15 times a week (high level of implementation). Evidently, 21.2% \((n = 54)\) were in the high level of implementation range as operationalized in this study. In total, those who reported using the innovation 6-10 or more times a week (moderate to high levels of implementation) constituted about 44% \((n = 111)\) of the those who used the innovation.

From these results, therefore, TALULAR as an instructional innovation has been implemented by the majority of science teachers in the Northern Region of Malawi with about half of them implementing it at lower levels and slightly less than half implementing at moderate to high levels. A very small proportion of science teachers 3.4% \((n = 9)\) did not adopt or
implement the innovation. Overall, the frequency of use of TALULAR showed that the innovation was in the moderate level of implementation (\( M = 2.69 \pm 3.0, SD = 1.043 \)).

Research Question Nine

What are the major concerns among secondary school science teachers regarding the innovation?

Summary of results

Item number 20, in part III of the survey, captured data for answering this question. In this item, respondents were asked to indicate whether or not they had any concerns regarding the innovation. A total 248 out of 269 responded to this item and 21 responses were missing. Of those who responded, 76.2% \( (n = 189) \) indicated that they had concerns, and 23.8% \( (n = 59) \) did not have any concerns. Those who had concerns were further asked to describe them, and the frequency counts of these concerns are summarized in Table N2 in appendix N.

Results revealed four major concerns of science teachers regarding the innovation: (a) time limitation, (b) ineffectiveness of the innovation, (c) need for training, and (d) scarcity of some local resources for the innovation. Regarding time limitation, 25% of teachers \( (n = 48) \) said that time constraints limited their use of the innovation. They pointed out that the innovation demanded extra time for planning, looking for resources, creating and modifying, producing, and trying the resources out before they could be used in the classroom. Others were concerned that the use of the innovation was a stumbling block to completing the long syllabi, while others said that they needed more time to use TALULAR in the classroom as the currently allocated time (40-45 minutes) was inadequate. In addition, others indicated that one needs to come up with enough TALULAR for use in large classes to allow everyone to handle or feel, and this demanded extra time, which was not at their disposal. 22% \( (n = 41) \) said that TALULAR as a
teaching tool was *ineffective*, especially when it is not well planned and used inappropriately. Some science teachers said that measurements and experimental results were inaccurate when TALULAR was used, while others pointed out that using TALULAR in some cases did not reflect the situation in reality and were concerned that it may bring about confusion and misconceptions. Other teachers were also concerned that students who did not have a chance to use real laboratory resources had difficulties in handling and using actual materials and equipment during national examinations. On the need for training, teachers’ main concern was that many of them were not trained on how to use the innovation for teaching. As such, they did not have the requisite knowledge and skills to implement it in the classroom. Out of the 363 participants who responded to the question on whether or not they had attended training for the innovation, 51% \((n = 134)\) reported that they had not yet undergone training. The fourth major concern was about the *scarcity of some local resources* to implement the innovation. Although the innovation is founded on the belief that local resources are available in the near environment, some teachers had to ‘hunt’ for the so called ‘local’ resources. These concerns limited the integration of the innovation in the classroom.

While the four concerns described in the preceding paragraph constitute major concerns, other minor concerns were as follows: (a) *inapplicability* of the innovation, where teachers indicated that the innovation did not work in cases where resources like chemicals or equipment such as microscopes, oscilloscopes, ammeters, and voltmeters were needed, (b) *inadequate funds*, where teachers needed financial resources to help them use the innovation as some resources needed to be purchased (such as nails) or funds were needed for teachers to travel in order to access them, (c) *difficult to design/create resources*, in which using the innovation required teachers to design/create or modify resources, causing concerns that to
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engage in such a process was a difficult task that required a lot of creativity, (d) limited reusability, where teachers pointed out that once they created and used the resources, reusability was limited because some could not be preserved due to either the cost of preservation chemicals, or lack of storage space, (e) lack of incentives, where teachers reiterated that acquiring some resources for the innovation was very demanding and sometimes risky, and incentives in the form of risk allowances and/or promotions would motivate them to integrate the innovation in the classroom, and (f) lack of commitment, in which teachers noted that they were receiving little if any support from the government through the ministry of education, as most schools did not have the basic resources and equipment to facilitate utilization of the innovation. In some cases, teachers had to pay for the expenses because the schools did not have money. Other teachers were concerned that some of their peers were not committed to using the innovation for teaching, either because they were not motivated or underrated its importance.

In summary, the most major concerns of science teachers about the innovation, in order of importance, were: (i) time limitation to use the innovation, (ii) ineffectiveness of the innovation in some cases, (iii) need for training, and (iv) scarcity of some needed resources to facilitate the use of the innovation for teaching.
Chapter 5: Discussion, summary, conclusions, and recommendations

This study was conducted to determine: (a) whether, and to what extent, the perceived characteristics of innovations and teachers’ demographic and employment variables were useful in predicting the level of implementation of TALULAR, and (b) the extent to which the TALULAR innovation has been implemented by secondary school science teachers in Malawi. A cross-sectional survey was used to collect data from secondary school science teachers teaching Physical Science, Biology, and Agriculture. Pearson correlation was used to investigate associations between perceptions of using TALULAR and implementation, and multiple regression was employed to determine the predictive value of perceptions of using TALULAR on implementation. One-way ANOVA and t-tests were used to determine if there were any significant differences in both perceptions of innovations and the level of implementation based respondents’ demographic and employment variables. The extent of TALULAR implementation was determined based on the proportion of respondents who reported using the innovation along with descriptive statistics on implementation as measured by the frequency of innovation usage.

Rogers’ diffusion of innovations (DOI) theory provided the theoretical framework for this study. At the most fundamental level, Rogers’ DOI theory is about social change as a result of the introduction of new ideas (innovations) in the social system and explains why some innovations are accepted or rejected by targeted organizational members. Literature on diffusion studies related to innovation adoption and implementation with respect to Rogers’ perceived attributes of innovations (PCIs) and participants’ demographic and employment variables was reviewed. These variables were key innovation factors to this study, however, the literature revealed inconsistent findings about the relationship between these factors and the adoption and implementation of the innovations, limiting their reliability in explaining and predicting adoption
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and implementation. This study provides cumulative empirical evidence not only about the relationship between perceived characteristics of innovations and the implementation of innovations but also on the usefulness of these perceived attributes in predicting the implementation of educational innovations in general, and TALULAR implementation in particular. In addition, the findings for this study provide information useful to change agencies and agents when planning a successful TALULAR diffusion campaign in Malawi.

This section presents a discussion of the main findings from Chapter 4. It will also summarize the main findings, provide conclusions, and suggest practical implications of the findings. Limitations of the findings will also be presented including recommendations for further research.

Discussion

The ever increasing demand for schooling and the subsequent dwindling of public school resources has challenged the ministry of education in Malawi to introduce TALULAR, an instructional innovation that is based on the use of locally available resources to ensure quality teaching and learning. As a supplement to other school resources, the important features of this innovation include its potential for sustainability and inexpensiveness as compared to generic or conventional factory-made resources, and its potential to bring about meaningful learning when effectively implemented. This study has shown that the secondary school subsector, especially in the sciences, still faces a myriad of problems that the ministry of education must address. Such problems include high student-to-teacher ratios and student-to-textbook ratios, inadequate or lack of basic resources for teaching science, and a high proportion of under qualified teachers in community day secondary schools (CDSSs). For instance, the overall student-to-teacher ratio of 151: 1 is still much higher than the 40:1 ratio targeted by the ministry of education in the quest to
improve the quality of secondary school education in Malawi (MoESC, 2001). While government efforts toward alleviating these problems should be commended, it should increase educational financing, provision of teaching and learning resources in schools, pre-service and in-service training, and teacher recruitment. Research has consistently shown that a better qualified teaching force and the adequate provision of teaching and learning resources are some of the strongest determinants of students’ performance (Fuller, 1987).

While one would expect CDSSs and CSSs to have similar quality science teachers, inequalities in teacher deployment in these schools have resulted in a majority of under qualified teachers in CDSSs. This situation has denied many capable students access to a better quality education overall, and a better quality science education in particular, and the ministry of education is urged to prioritize addressing this inequality. In this investigation, results have also revealed that most CDSSs science teachers have comparatively lighter teaching loads far below the required minimum than those in CSSs. This finding is in sharp contrast to the general perception about the existing shortage of science teachers in public schools. Either the presence of comparatively more teachers in CDSSs than in CSSs or the fewer number of science subjects offered in CDSSs than in CSSs seems to be a plausible explanation for this finding. It should be noted, however, that a greater proportion of these CDSS science teachers are under qualified and the ministry needs to prioritize and increase in-service training for them.

Relationship between perceived characteristics of using TALULAR and implementation

After investigating the relationship between perceptions of using TALULAR and the level of its implementation, the findings of this study revealed that relative advantage, ease of use, compatibility with prior experience, others’ use, communicability, measurability, trialability and image were significantly and positively related to TALULAR implementation. Only
perceived compatibility with values was not statistically significant, contrary to the observation by Klein and Sorra (1996) that organizational members’ commitment to using an innovation depends on the perceived compatibility with their values. Voluntariness, on the other hand, was negatively related to implementation, which was in agreement with previous findings by Agarwal and Prasad (1997). While studying diffusion of innovations, Moore et al. (1991) recommended establishing whether or not end users feel that they have the freedom to accept or reject the innovation. Although TALULAR is not strictly mandatory, science teachers, on average, perceived using the innovation to be less voluntary ($M = 2.219$, $SD = .604$). Their perception that they were required to use the innovation tended to be associated with increased levels of implementation.

While most of these results were anticipated and are generally consistent with previous findings especially on innovation adoption and implementation (Agarwal et al., 1997; Hughes & Keith, 1980; Rogers, 2003; Sooknanan et al., 2002; Tornatzky et al., 1982), they also countered those of Hughes et al. (1980) and Sooknanan et al. (2002). Hughes et al (1980) did not find any significant relationship between the perceived complexity (ease of use) associated with the elementary science curricula and the degree of its implementation. Similarly, Sooknanan et al. (2002) found no relationship between the perceived complexity in using computers and the degree of implementation. In addition, the results of this study contradicted findings by Goldman (1994), who found no statistically significant associations between implementation of a nation-wide health education campaign and its perceived trialability and compatibility. It is important, however, to point out that perceived compatibility as used in Goldman’s study was not refined into separate sub-constructs of compatibility with prior experience and compatibility with values.
as used in this study and other previous studies by Compeau et al. (2007) and Moore et al. (1991).

It should also be noted that even though perceived compatibility with prior experience and voluntariness emerged as significant factors influencing TALULAR implementation, such findings should be interpreted with caution because of low internal consistency reliabilities for these scales. Overall, the findings emphasize the significance of perceived innovation characteristics to the implementation of an innovation.

Utility value of perceived attributes of using innovations in the prediction of TALULAR implementation

Both collective and independent contributions of the perceived attributes of using innovations in predicting implementation of TALULAR were evaluated using simultaneous multiple regression analysis. Results indicated that these innovation factors collectively accounted for nearly 13% of variance in implementation of TALULAR. Even though this accounted variance was statistically significant and is categorized as a large effect size according to Kinnear et al. (2008), a larger proportion of accounted variance was expected based on previous studies. In previous diffusion studies, Rogers (2003) noted that the perceived characteristics of innovations explained about 87% variance in the rate of adoption, while in a study involving teachers’ current usage of the World Wide Web, these variables accounted for 48% of variance in the WWW usage (Agarwal et al., 1997). It should be noted, however, that contextual factors such as differences in innovations studied and group of respondents involved may bring about such disparities in findings.

An investigation of the independent contribution of each of the innovation factors revealed that perceived relative advantage, ease of use, and observability in terms of other’s use
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significantly contributed in accounting for variance in the implementation. Relative advantage emerged to be the most important predictor of TALULAR implementation; controlling for other variables, a unit increase in the perceived relative advantage was related to .490 unit increases (or .248 standard deviation unit increases) in the predicted level of implementation. Surprisingly, perceived ease of use had a negative contribution to the predicted level of implementation. Based on its positive correlation with implementation, it was anticipated that ease of use would have a positive influence on the predicted level implementation. This result suggests the existence of a suppressor variable in the prediction model that needs to be investigated in future studies.

The initial model was revised so that only variables substantially contributing to accounting for variance in implementation were included in the model. Perceived image become significant after some variables were systematically eliminated. The resulting model consisted of four variables (perceived relative advantage, ease of use, other’ use, and image) and accounted for essentially the same amount of variance (~13%). These four variables could be used to the same degree of confidence to predict the level of implementation as the original model using all the seven variables.

Value of perceived attributes of using innovations in the prediction of TALULAR implementation after controlling for respondents’ demographic and employment variables

Demographic and employment variables. Previous studies have found inconsistent findings regarding the relationship between innovation acceptance and usage and demographic and employment variables such as the level of education (Chapman, 2003; Li et al., 2007; Rogers, 2003; Waller et al., 1998), gender (Adams, 2002; Li & Lindner, 2007), and teaching experience (Adams, 2002; Watson, 2007). In this study, before employment and demographic variables (gender, level of education, teaching experience, type of school, training attendance,
and length of training) were controlled for, their relationships with TALULAR implementation were investigated. In the present study, only the level of education, school type, and training attendance were significantly related to implementation. No significant associations between implementation and gender, teaching experience, or length of innovation training were found. Findings of this study revealed that the higher the respondent’s level of education, the less frequently they used TALULAR in their teaching. While this did not lend support to the positive relationship between the level of education and innovation adoption behavior found by Rogers (2003) and Caswell, Fuglie, Ingram, Jans and Kascak (2001), nor did it support findings by Chapman (2003) who found no relationship, it did agree with earlier findings by Li and Lindner (2007) and Harper et al. (1990). Even though adequate former education has been found to help targeted organizational members to be more innovative as far as innovation acceptance or adoption is concerned (Caswell, et al., 2001; Rogers, 2003), this study also suggests that factors important in facilitating innovation adoption (in this case, the level of education in this case) may in fact hinder innovation implementation.

The type of school where teachers were assigned (CDSS or CSS) was negatively related to implementation of TALULAR, and teachers in CSSs were associated with lower levels of implementation. Based on the literature review and results of this study, this finding emphasizes the existing differences between CDSSs and CSSs in terms of teacher qualifications, total number of teachers, and availability of teaching and learning resources. Comparatively, CSSs have more science teachers who have higher levels of education, fewer science teachers with relatively higher teaching loads, and relatively more resources than CDSSs. Therefore, science teachers in CSSs may either not have adequate time to utilize the innovation in the classroom.
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because of heavier teaching loads or may not find as much need for the innovation because they have some of the basic resources.

It was surprising to note that training attendance was related to implementation while length of training was not. It is logical to argue that the extent to which participants of a training workshop acquire in-depth knowledge and skills related to the utilization of the innovation is dependent on the intensity and extensiveness of the training rather than mere training attendance.

Previous research has supported the notion that the amount or length of training is related to the frequency of innovation usage (Wozney et al., 2006). In general, there is substantial amount of previous research showing that training is a significant determinant of innovation implementation (Ely, 1990; Eylon & Bagno, 1997; McCormick et al., 1995; Wozney et al., 2006). While the two dimensions of training may be considered distinct, there is obviously a relationship between them; through training attendance potential users are exposed to and acquire new knowledge about the innovation. In addition, training attendees have the opportunity to learn and judge the innovation’s perceived relative benefits, and its perceived fit with existing need, values, and practices. In general, these findings provide evidence on the importance of considering social and contextual factors apart from the perceived innovation attributes when studying the diffusion of innovations.

Controlling for demographic variables. This study also sought to investigate the value of the perceived attributes of using innovations in the prediction of TALULAR implementation after controlling for respondents’ demographic and employment variables. It should be noted that the motivation for investigating this predictive value after having controlled for respondents’ personal variables was due to the suspicion (based on previous studies) that the influence of perceptions of using innovations may be moderated by respondents’ demographic variables such
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as level of education, gender, teaching experience, school type, and training. When the influence of demographic and employment variables (level of education, training attendance, and school type) was controlled for, the perceived innovation attributes significantly predicted implementation. However, the total variance accounted for (9%) was lower compared to the one before demographic and employment variables were controlled for. Such a finding may suggest the need for further empirical studies to investigate whether or not perceptions of using innovations may in fact be influenced by some of the respondents’ demographic and employment variables. In such studies, causal models (variable mediation) and variable interaction effects (variable mediation) could also be explored. Although relatively small, the 4.5% of variance in implementation accounted for by the demographic and employment variables was also significant and cannot be disregarded for practical purposes. Given the general paucity of previous empirical studies that specifically investigated the relationship between demographic and employment variables and implementation of innovations, additional diffusion studies to replicate and validate these findings are recommended.

**Parsimonious prediction model of TALULAR implementation**

A useful but frugal prediction model that could maximize the prediction of TALULAR implementation was sought by considering both the perceptions of using innovations and respondents’ demographic and employment variables collectively. Using stepwise regression analysis, two variables contributing substantially to the prediction power of the model, namely, the perceived relative advantage (which accounted for most of the variance) and others’ use, collectively accounted for nearly 14% of variance in the implementation. Other studies have also found similar findings where perceived relative advantage has been found to be the strongest predictor of innovation assimilation and implementation (Agarwal & Prasad, 1997; Askarany et
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al., 2007; Davis, 1989). In this study, science teachers had a positive perception regarding the relative advantage of using TALULAR compared to either lecturing, which is a teacher-centered approach generally preferred when resources are lacking, or using commercially-based teaching and resources that were inadequate or inexistent in schools. In particular, they perceived that using TALULAR enabled them to: (a) accomplish tasks easier and increases their productivity, (b) improve the quality of teaching, (c) have greater control over their work, and (d) access resources within their local environment at a relatively cheaper cost. This finding underscores the importance of teacher training in which training programs should emphasize the relative benefits of using the innovation in order to convince teachers to support the new idea and, more importantly, routinely use it as teaching tool in their classrooms. Perceived observability in terms of others’ use was the second most important predictor of TALULAR implementation. Overall, science teachers tended to view the use of the innovation by others as a significant and positive influence to use the innovation. This finding suggests that through informal interactions with fellow teachers within the school setting, teachers became more knowledgeable about the innovation and its usefulness as a teaching tool and were pressured to use it in order to conform to school norms (Zhao & Franck, 2003). In other words, one of the greatest influences on teachers’ use of TALULAR was the observed use of the innovation by their peers. This finding is consistent with the diffusion of innovations theory, particularly on the significant role played by the perceived observability of innovations in the diffusion process (Rogers, 2003). According to Rogers, innovations that are perceived as having greater observability (which relates to the degree to which potential users are able to see the innovation being used by others in the adoption context) than their counterparts have a more rapid rate of adoption.
Even though the percentage of variance accounted for by the perceived relative advantage and others’ use was statistically significant, a much bigger proportion-in light of previous findings-was expected in order for findings to have a much more practical utility. In previous studies, perceived innovation characteristics have accounted for much higher proportions of variance in implementation. In a study that investigated the relationship between perceptions of an elementary science curricula and the extent to which it was implemented by teachers, perceptions of innovations accounted for 40.1% of variance in the observed degree of implementation (Hughes et al., 1980). Other scholars have also found much higher proportions of variance accounted for by the perceived characteristics of innovations. For instance, studies conducted by Meyer et al. (1988), Kaluzny et al. (1973), Yetton et al. (1999) have found perceptions of innovations to account for 77%, 58%, and 27% of variance in innovation implementation, respectively. It should be noted, however, that these studies have multiple features different from this study. For instance, the perceived innovation attributed used by Meyer (1988) did not explicitly draw from the perceived characteristics as operationalized by Rogers (1983) in his diffusion of innovations theory. It should also be pointed out that the proportion (14%) of variance in implementation accounted for by the perceptions of using TALULAR in this study was not very different from the one (18%) found by Goldman (1994). However, Goldman studied the relationship between perceived innovation characteristics and implementation in a different context; he studied a health related voluntary innovation in a non-profit corporate organization. These findings generally support observations by Rogers (1995) and Compeau et al. (2007) that factors important in the diffusion of innovations may vary from context to context and from one innovation to another.
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In general, the trend in findings of previous studies suggests that a much larger proportion of variance in the implementation would have been accounted for in this study, especially that demographic and employment variables and perceptions relevant to the implementation of TALULAR were considered collectively. However, it should be noted that previous studies reviewed herein were done in different contexts, meaning that different types of innovations and respondents were involved. The other plausible explanation for the lower proportion of variance in TALULAR implementation accounted for in this study is that some of the relevant variables (attributes of innovation constructs) were excluded in the running the prediction model owing to their low internal consistency reliabilities. Pedhazur (1997) noted that when relevant variables that are correlated with other variables in the model have been excluded in the regression model, the estimation of regression coefficients for variables in the model is biased. It should be noted, however, that results of a stepwise regression analysis were to a larger extent similar to those from simultaneous regression analysis when only predictors contributing significantly in accounting for variance in implementation were considered.

Differences in perceptions and level of implementation by demographic/employment variables

This study also examined differences in perceptions and the level of TALULAR implementation based on respondents’ gender, school type, training, level of education, teaching experience, and length of training. While results did not reveal any significant differences in the level of implementation based on respondent’s gender, level of education, teaching experience or length of training, differences in the level of implementation were found in relation to school type and training attendance. In addition, differences in perceptions of using TALULAR were found in relation to school type, training attendance, level of education and teaching experience.
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TALULAR being a science-related technological and instructional innovation, male teachers were anticipated to implement it at higher levels than female teachers due to the observed gender differences in science teaching self-efficacy (Riggs, 1991) and technology teaching self-efficacy (Watson, 2007). Findings by Riggs, and Watson, who found that females had lower science teaching self-efficacy, and lower teaching with technology self-efficacy, respectively, suggested that females are less likely to adopt and implement technological and instructional innovations than males. However, there was no evidence, based on findings of this study, that differences between male and female science teaching self-efficacy and technology teaching self-efficacy had any significant influence on the implementation of TALULAR nor did gender emerge as an important determinant of how respondents’ perceived using the innovation.

Findings of this study also revealed that teachers who were in CDSSs implemented the innovation at significantly higher levels than those in CSSs. This finding may reflect teacher qualification and resource inequalities between these two types of public secondary schools. Generally, CSSs have more qualified teachers and are better off in terms of the availability of basic teaching and learning resources. African teachers who are not well prepared have been found to exhibit negative attitudes toward science (Salisbury, 1985). Rao (1994) and Sooknanan et al. (2002) found that attitudes significantly influence innovation acceptance and implementation. Previous findings have also provided evidence that the adequate availability of resources is an important determinant of innovation implementation (Ely 1990, 1999a; Murphy, 1998). Therefore, teachers in CSSs were expected to implement the innovation at higher levels than those in CDSSs. However, contrary to this expectation, it was the under qualified teachers in CDSSs working under less favorable conditions with an acute shortage of teaching and learning resources that implemented the innovation at higher levels. One possible explanation for
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This finding could be that the acute shortage of teaching and learning resources motivated CDSSs teachers’ more frequent use of TALULAR. In other words, these teachers saw a greater need for TALULAR than those in CSSs and accepted it as a much better solution to their instructional problems. Another plausible explanation could be related to the fact that relatively more (50%) teachers in CDSSs had undergone training for the innovation compared to those (47%) in CSSs. Therefore, training might have prepared more CDSS teachers with more essential knowledge and skills to use the innovation as an instructional tool than those in CSSs.

Regarding training, those who had training on the use of the innovation reported significantly higher levels of implementation than those who did not. This finding is consistent with previous research findings, which seem to agree on the importance of training in facilitating implementation of innovations (Armstrong, 1996; Beggs, 2000; Ely 1990, 1999a). As noted by Klein et al (1996), training enables end-users to acquire essential knowledge and skills in order for them to implement innovations. It was not surprising, therefore, to note that science teachers who had undergone training also had significantly more favorable perceptions of using the innovation than those who were not trained. The fact that a greater proportion of teachers in CDSSs had undergone training compared to those in CSSs could explain why teachers in CDSSs perceived using the innovation significantly more favorably in relation to its perceived benefits (relative advantage), compatibility with prior experience and values, observability in terms of others’ use, ease of use, and trialability. In addition, this implied that in the perspective of CDSS teachers, the need for the innovation to solve their instructional problems associated with the shortage of resources was so important that it surpassed any obstacles related to innovation implementation. On the other hand, the frequency with which respondents used TALULAR as a teaching tool and how they perceived using it did not depend on the length of training. These
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findings, especially where respondents did not differ in their levels of TALULAR implementation based on length of training, disagree with findings by Wozney et al. (2006), who found that the length of training was significantly related to the observed differences among innovation users in their reported levels of implementation.

Another important finding in this study was that respondents who had a bachelor’s degree rated the perceptions of using TALULAR (except for perceived voluntariness of use) significantly lower than those who either had a diploma or an MSCE qualification. Such a finding is in sharp contradiction to previous research findings, which have suggested that more educated innovation users (most of whom are in CSSs in this case) are more innovative and more proficient at overcoming obstacles associated with innovation implementation (Bauer et al., 2005). The fact that respondents with higher levels of education perceived the innovation to be more voluntary than those with lower qualifications may suggest the existence of misunderstandings about the innovation based on the sources of information. This finding also seem to suggest that contextual needs for the innovation and associated innovation training may be more important to end-users in facilitating innovation implementation than their educational qualifications. In general, science teachers’ perceptions of using TALULAR differed by their level of education.

An investigation of differences in perceptions of using TALULAR in relation to teaching experience revealed significant differences in the perceptions of relative advantage, image and voluntariness. Even though there were no differences in perceptions of using TALULAR among science teachers who had taught for 4-10 years, 11-14 years, 15-20 years, or more than 20 years, findings showed that less experienced teachers (0-3 years of teaching experience) rated perceptions of relative advantage and image for the innovation lower than the more senior ones.
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with at least 4 years teaching experience. This finding provided evidence to one of the arguments raised in this study that demographic and employment variables seem to influence implementation by shaping users’ perceptions of using the innovations. In fact, Liao and Lu (2008) found that the influence of perceived innovation characteristics on users’ intention to use the e-learning services innovation (where intention to use was related to actual use) varied based on learner experience. Specifically, study findings by Li et al. (2007) revealed that educators with more years of teaching experience tended to be in later stages in the innovation-decision process than those with fewer years of teaching experience. The implication for this finding is that more experienced users are more likely to adopt and implement innovations than the less experienced ones. In this study, it was not surprising, therefore, that more experienced science teachers perceived using TALULAR more favorably in terms of its relative benefits (relative advantage) and its ability to improve their social status (image). One reasonable explanation for this finding is that more experienced innovation users tend to be more involved in innovation-related decisions, and eventually begin to perceive themselves as more capable of overcoming obstacles and uncertainties related to innovation adoption and implementation (Perkins et al., 1990). In addition, Chiesi et al. (1979) also noted that more experienced users tend to seek more information about new ideas and focus their attention on the most essential and relevant aspects of the innovation. This behavior is likely to cause more experienced teachers to better understand new ideas and solve challenges associated with them.

On the other hand, less experienced science teachers perceived using TALULAR to be more voluntary than the more experienced ones. While this finding may point to a general misunderstanding that science teachers have regarding the innovation, it may also mirror views held by more experienced teachers who might consider the innovation as a threat poised to make
them relinquish their long-cherished instructional practices. Looking at this finding from a different angle, new teachers joining the teaching profession may consider the innovation as a possible option in cases where instructional resources or materials are lacking or are inadequate, which is more likely the way they were taught during their teacher preparation. Viewed from the perspective of more experienced teachers who have been in the field for a longer period of time and have met reality face-to-face, the use of TALULAR may be considered a necessity if at all meaningful learning (in the context of acute shortage of resources) is to take place. In summary, science teachers’ perceptions of using TALULAR differed significantly by their teaching experience.

*Differences in teachers’ perceived characteristics of using TALULAR by frequency of use*

This study also sought to determine whether or not the perceived characteristics of using TALULAR varied for different groups in relation to the frequency of use. Findings revealed that science teachers who did not use the innovation at all rated perceptions of relative advantage, observability in terms of measurability and communicability, compatibility with prior experience, and image lower than those who used it at least once a week. Those who used it a few times a week (1-5 times a week) tended to rate these perceived characteristics of using TALULAR significantly lower than those who used it at least 6 times a week. There were no differences in perceptions of using TALLAR among teachers who used it at least 6 times a week. It is logical to consider teachers who used the innovation more frequently to possess more experience working with the innovation than those who did not use it all or only a few times a week (1-5 times a week). These findings seem to suggest that accumulated experience in teaching with TALULAR improves teachers’ enthusiasm and positions them to be more capable in resolving challenges and uncertainties associated with the innovation. In addition, their
experience with the innovation apparently enables them to pass evaluative judgments about the relative benefits of the innovation, its compatibility with their experiences and values, its impact on their practices, and how easily the results of using the innovation could be assessed and communicated to others. As such, those who used the innovation more intensely are more likely to perceive its use more favorably than non-users or infrequent users.

Another finding revealed that those who did not use TALULAR at all, or used it less frequently (1-5 times a week), perceived it to be more voluntary than those who used it more frequently. This seems to suggest that the absence of external pressure and the freedom to exercise their free will in deciding to use the innovation influenced, to a larger extent, their observed non-usage or low level of usage. This finding was consistent with one of the findings of this study where perceived voluntariness of use was negatively related to implementation, meaning that the more voluntary potential users perceive the use of TALULAR the less likely they are to implement it. While Rogers (2003) observed that forced or mandated innovations may in some cases influence potential users to adopt innovations, the findings in this study also provide evidence that some factors that may facilitate the initial acceptance of innovations may in fact hamper implementation. The results also support earlier findings in which perceived voluntariness has been found to negatively influence innovation acceptance and usage (Agarwal et al., 1997; Compeau et al., 2007). Although Ram and Jung (1991) found that forced innovations have negative impacts on adopters’ acceptance behavior (even for the most innovative individuals), the findings in this study suggest that some form of external pressure in the form of mandates or directives from superiors may be important in giving the innovation its initial usage momentum.
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Extent of TALULAR implementation

One of the objectives for this study was to establish the extent to which TALULAR has been implemented by secondary school science teachers. Findings revealed that almost all teachers (99%) had accepted or adopted the innovation, slightly more than 97% of teachers reported using the innovation in their classrooms, and based on statistical inferences and how the level of implementation was operationalized in this study, the implementation of TALULAR was at a moderate level. The observed gap in the proportion of teachers who reported having adopted the innovation and those who were actually using it does not come as a surprise and could mirror the observed challenges associated with innovation implementation that have been well documented in literature (Klein & Sorra, 1996; Klein & Knight, 2005; Rogers, 2003). A further analysis of findings revealed that of those who reported using TALULAR, slightly more than half (55%) implemented it less frequently (used it 1-5 times a week) and 44% implemented it at moderate to high levels (used it 6-10 times a week or higher). These findings also suggest that users’ positive perceptions about a new idea and its acceptance does not guarantee that they will actually use the innovation on a routine basis and in a committed manner. Klein and Knight (2005) contended that innovation implementation can only be considered successful if targeted organizational members actually use the new idea regularly, in a consistent and committed manner. While it is evident that a greater proportion of science teachers reported using the innovation, it is evident that not all used it more frequently and in a committed and consistent manner. It is, therefore, logical to conclude that implementation of TALULAR by secondary school science teachers is at a moderate level and the innovation is at the early stage of implementation and has not yet been routinized. It should also be noted that while the problem of lack of teaching and learning resources is not uniform among schools, which may determine the
necessity of using TALULAR, the proportion of those using it at lower levels is much higher than what would have been expected when compared to the severity of the problem. These findings also confirm assumptions of this study in which TALULAR was assumed to have been adopted by science teachers and was at the implementation stage but had not yet reached the routinization stage.

*Teachers’ major concerns regarding the use of TALULAR*

It was considered important to capture teachers’ concerns regarding the use of TALULAR in their classrooms because they could illuminate important information about factors impeding the implementation of the innovation. In addition, understanding teachers’ concerns may help to determine the nature and extent of the assistance teachers need in order to successfully implement the new idea (Christou, Eliophotou-Menon, & Philippou, 2004).

The number one major concern expressed by teachers was related to *time limitation*. They were concerned that using TALULAR demanded more time for planning, looking for resources, and designing, developing, and trying the resources out before they could be used in the classroom. Others were concerned that the 40-45 minutes teaching periods made it difficult to accomplish anything substantial with TALULAR, and yet others said that using the innovation was a stumbling block to completing the long syllabi. These findings also support previous study findings in which time limitation has been found to be a common concern among users hindering the implementation of instructional innovations (Dass, 2001; Stokes & Wilson, 2000; Zhao & Frank, 2003). Levi and Dickie (1973) argued that the selection of media (specifically, media attributes) for teaching and learning should, among other things, match the nature of learning task, learner aptitude, cognitive and personality characteristics of learners. This process underscores the importance of adequate planning time for teachers to effectively use TALULAR.
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This study also revealed that most science teachers, especially those in CDSSs (where the shortage of resources is acute and the use of TALULAR is critical), had less than the required minimum teaching loads. Therefore, some of them could be given release time to develop resources for the innovation. Hull (1975) observed that release time is essential especially when new ideas, like TALULAR, require that users design and develop materials. Even though the lack of adequate time may actually limit the use of the innovation, teachers could benefit from planning well ahead of time and working collaboratively with fellow teachers, students, and parents in locating, designing, developing, and producing materials.

The concern that the use of TALULAR was a stumbling block to completing syllabi reflects teachers’ values and beliefs about teaching, and shows that their teaching appears to be most influenced by the need to prepare students for national examinations. Thus, teachers prefer teacher-centered approaches that seem to be most efficient for transmitting information (Kalande, 2006; Lungu, 2005) over the student-centered pedagogical science approaches that are based on sound theoretical underpinnings. This means that for successful innovation implementation to be realized, change efforts should target both teachers’ knowledge and skills but more importantly, their values and pedagogical beliefs.

The second major concern expressed by teachers was the Ineffectiveness of the innovation itself as an instructional tool. While some of them attached a condition to this concern, namely, that the innovation was ineffective if not well planned and appropriately used, others were specific and pointed out that using TALULAR not only yielded inaccurate measurements and experimental results but also could potentially be a source of confusion and student misconceptions. Others indicated that the use of TALULAR caused students difficulties when working with actual or conventional materials and equipment during public examinations.
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These concerns illuminate those areas in which teachers need assistance. They need to be trained on how to use the innovation appropriately so that it benefits not only themselves but also the students for whom they are responsible. For instance, teachers need to see how the use of the innovation fits with science pedagogy, they need help in selecting, designing, developing and producing materials or resources that are congruent with learning tasks, students’ aptitudes, their learning styles, and cognitive characteristics so that optimal learning is realized. In addition, teachers need to better understand the capabilities of the innovation in practice and its limitations. Kirkgoz (2008) observed that unless teachers understand the innovation adequately, actual and continued use of the innovation in the classroom will be hampered. Therefore, teachers may also need simple practical examples of successful lessons with TALULAR to be convinced of its benefits and to enable them model such techniques in their classroom contexts. As pointed out by Thompson (1992), if teachers cannot be convinced that change will bring significant benefits to themselves and their students, there is a greater likelihood that they will resist it.

The third major concern was the need for training. Training has consistently been found to be one of the important facilitators of innovation implementation (Ely, 1990, 1999a; Hubbard et al., 1997; Kirkgoz, 2008; McCormick et al., 1995; Stokes et al., 2000). Data for this study showed that slightly more than half of teachers surveyed had not yet undergone TALULAR training. Change agents and agencies involve in the diffusion of TALULAR should ensure that all teachers are adequately trained if they are going to implement the innovation in their classrooms on a large scale. In addition, data showed that the majority of participants (61%) had 5-7 hour training workshops corresponding to one-day training. Some of the challenges highlighted by teachers associated with the implementation of TALULAR could be due to
inadequate training. It is well documented that one-day or one-off training workshops, as generally practiced in the TALULAR context, are insufficient to enable teachers to acquire essential skills and technical and pedagogical content knowledge for successful implementation of innovations (Elyon & Bagno, 1997; Fullan, 1991; Stevens, 2004; Wozney et al., 2006).

**Scarcity of some local resources** was the fourth major concern relevant to the implementation of TALULAR that was expressed by teachers. Teachers pointed out that sometimes they have to use their own limited funds for travel to locate and even purchase some of the resources. Even though such a finding appears to be in sharp contradiction to the assumptions that resources needed for the implementation of the innovation are generally inexpensive and are available within teachers’ environment, such concerns may reflect the day-to-day realities that teachers face as they struggle to implement the innovation in the classroom. On the other hand, this may reflect misunderstandings about what constitutes the innovation, and the lack of creativity on the part of users. It should be noted, however, that if teachers do perceive that resources needed for them to implement the innovation are inadequate or unavailable, they are more likely not to implement the innovation to the extent expected by innovation advocates. Research has consistently shown that the availability of adequate materials or other instructional resources is an important determinant or facilitator of innovation implementation (Ely, 1990, 1999a; Kirkgoz, 2008; Murphy, 1998; Surry & Ensminger, 2003).

While the four concerns discussed in the preceding sections constitute the major concerns expressed by science teachers, there were other ‘minor’ (less frequent) ones that could also aid in understanding some of the obstacles that teachers face in the implementation of TALULAR and point to the kind of assistance they may need. For instance, the concerns about: (i) inapplicability of the innovation is some contexts, and (ii) difficulty to design or create
resources for the innovation suggest the need for adequate training so that teachers understand both the capabilities and limits of the innovation; (iii) inadequate funds and lack of adequate government support suggest the need for the government to adequately finance secondary education; (iv) limited reusability of materials or resources associated with the innovation because of lack of storage space suggests the need for concerted efforts among various stakeholders (parents, NGOs, Ministry of Education) to assist with the construction of schools facilities to be used for storing materials and other instructional resources for future use; (v) lack of incentives may suggest that teachers need some form of rewards for their efforts and commitment in implementing the innovation in the classroom, and such rewards could be in form of promotions, awards and recognition; and (vi) lack of commitment on the part of some teachers in using the innovation may suggest the need for more training and vicarious observational learning opportunities so that such teachers can fully understand the innovation and its associated benefits to be motivated to use.

In summary, the distinction between major and minor concerns should not be interpreted to mean that some concerns are more important than others but rather should be viewed in terms of the most and least frequently expressed apprehensions, which suggest need areas to be prioritized to support teachers in their implementation efforts. It should be noted that these concerns could also be better understood when viewed in the context of the Concerns Based Adoption Model (CBAM) developed by Hord, Rutherford, Huling-Austin, and Hall (1987), which is useful for understanding teachers’ concerns and the impact new instructional ideas may have on their professional practices (Christou et al., 2004). Even though open-ended questions (as attempted in this study) could be used to assess teachers’ concerns (Hall & Hord, 2001), such concerns could systematically and comprehensively be assessed by using the stages of concerns
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(SoC) questionnaire. For this reason, and because of limited space in this paper, such an approach will not be undertaken and is left for consideration in future studies. Therefore, it suffices to say that the concerns discussed above relate to the following stages of concerns: (a) stage 1: Informational, where teachers have expressed willingness to learn more about TALULAR through training, (b) stage 2: Personal, where teachers concerns focused on how the use of TALULAR would affect them personally; for instance, their concern about time limitation and personal expenses incurred in mobilizing resources, (c) Stage 3: management, in which case teachers were concerned about the amount of time required to teach using the innovation, and their concern about finding appropriate ways of teaching using the innovation so that meaningful learning takes place, and ensuring that students’ skills are better transferred to contexts where conventional resources are used especially during public examinations, and (d) stage 4: consequence, where concerns centered on the impact on students’ learning when using the innovation. For instance, their concern that students may find it difficult to understand some concepts and may end up internalizing misconceptions. Also the concern about the students’ difficulty in transferring handling skills acquired when working with TALULAR materials or equipment to contexts where conventional materials are available.

Summary and conclusions

Summary

The study was designed to determine: (a) whether, and to what extent, the perceived characteristics of innovations and teachers’ demographic and employment characteristics are useful in predicting the level of TALULAR implementation, and (b) the extent to which the innovation has been implemented by secondary school science teachers. The results indicated significant relationships between each perceived characteristic of using TALULAR (with the
exception of compatibility with values) and the level of implementation. When perceptions of
innovations were considered collectively, they predicted the level of TALULAR implementation
and accounted for nearly 13% of the variance in the level of implementation. However, when
these perceptions were considered independently, only perceived relative advantage, ease of use,
others’ use, and image predicted the level of implementation and still accounted for nearly the
same amount of variance in implementation. Controlling for other variables, perceived relative
advantage was the strongest predictor of implementation.

On the relationship between demographic and employment variables and implementation,
findings revealed that respondents level of education and the type of school where they taught
were negatively related to implementation, while training attendance was positively related to
implementation. The other demographic variables (gender, teaching experience, and length of
training) were not associated with the implementation of the innovation. When the influence of
demographic and employment variables were controlled for in evaluating the collective value of
perceptions of innovations in predicting implementation, the perceptions still predicted
TALULAR implementation but they collectively accounted for less variance in implementation.
When the model was refined by excluding perception of innovation constructs that did not
substantially contribute to the prediction power of the model, relative advantage, ease of use, and
others’ use remained in the model, and perceived relative advantage was still the strongest
predictor of implementation.

The study also sought to find the single best model that would optimize the prediction of
TALULAR implementation by considering perceptions of innovations and demographic and
employment variables together. Findings revealed that perceived relative advantage, which
accounted for the most variance, and others’ use were the only two important predictors that
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constituted the most parsimonious model for optimizing the prediction of TALULAR implementation. When differences in the implementation of TALULAR and perceived characteristics of using the innovation in relation to respondents’ demographic and employment variables were examined, findings revealed differences in the level of implementation and in the perceptions of using the innovation by school type and training attendance. Respondents in CDSSs implemented the innovation at higher levels and generally perceived the use of the innovation more favorably than those in CSSs. In addition, respondents with lower levels of educational qualification (i.e., diploma or MSCE) tended to perceive the use of the innovation more favorably than those with higher qualifications. However, there were no significant differences in perceptions of using the innovation between respondents with diplomas and those with MSCE. In relation to teaching experience, findings showed that less experienced science teachers tended to rate perceptions of using the innovation significantly lower than the more experienced ones.

In regard to differences in teachers’ perceptions of using TALULAR based on the frequency of the innovation usage, findings revealed that those who did not use the innovation at all, and those who used it 1-5 times a week, rated the perceived characteristics of using the innovation significantly less than those who at least used it once a week, and those who used it at least 6 times a week, respectively. However, those who did not use it at all, and those who used it 1-5 times a week, perceived the use of the innovation to be more voluntary than those who at least used it once a week, and those who used it between 6-10 times a week, respectively. Findings also revealed that TALULAR has so far been implemented at a moderate level since the beginning of the diffusion campaign more than seven years ago. Teachers also expressed a number of concerns related to the use of TALULAR. Four major concerns were: time limitation,
ineffectiveness of the innovation, need for training, and the scarcity of some resources needed to use the innovation.

Conclusions

Consistent with previous findings, the present research findings confirmed the importance of perceptions of innovations as determinants of innovation implementation. Among the perceived characteristics of using innovations, the findings of this study suggest that relative advantage and others’ use are the two most important factors for optimizing the prediction of TALULAR implementation. In addition, findings suggest that personal variables may influence innovation implementation directly or indirectly by shaping users’ perceptions regarding the use of new ideas. The perceptions of using TALULAR studied in this research accounted for a comparatively smaller amount of variance in the level of implementation than what previous studies had found (Goldman, 1994; Hughes et al., 1980; Kaluzny et al., 1973). This provided evidence, as observed by Rogers (1995), that perceptions of innovations may not be the only important factors influencing innovation acceptance and usage. These findings, therefore, also suggest that other contextual and social variables may be important determinants of TALULAR implementation. In addition, factors that have been found to be positively related to adoption of innovations, such as perceived ease of use and voluntariness of use, have been found to be negatively related to TALULAR implementation. These findings, therefore, imply that some factors which may positively influence adoption could in fact hinder implementation of innovations. Furthermore, the findings of this study suggest that scholars, especially those in the developing world, should be cautious when adopting findings of studies done in the developed countries or western contexts. Likewise, extra caution should be exercised when modifying and using measures developed and validated in other contexts for they may not work as effectively as
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anticipated. Finally, findings suggest that implementation is a complex and dynamic process that may involve the interplay of many factors. Therefore, in order to identify all the critical factors relevant to the implementation of TALULAR, a holistic approach to studying the innovation implementation should be undertaken. Teachers also need to be supported in their efforts to implement the innovation in the classroom. Lack of support at the time when innovation users need it the most is one of the major obstacles to successful innovation implementation. In regards to the implementation of TALULAR, support should be in the areas of training, continued technical and pedagogical support, teaching materials or resources, and giving teachers different forms of incentives. Unless teachers see the benefits of TALULAR and policy makers’ commitment to the innovation, they will not use it in their classrooms in a consistent and committed manner.

Practical implications

The findings of this study have significant implications that could inform policy makers, in-service and pre-service teacher trainers or change agents, and secondary school science teachers.

Policy makers

This study is perhaps among the very few, if not the only one, that has attempted to examine factors important in the implementation of TALULAR among secondary school science teachers from a diffusion of innovations perspective. Five specific policy issues that could facilitate teachers’ implementation of the innovation have been identified. First, teachers’ perception that the use of TALULAR is voluntary has been found to negatively influence the implementation of the innovation. In fact, those who did not use the innovation at all considered it to be more voluntary than those who used it. Therefore, some kind of external pressure in the
form of mandates or directives from the education divisions or the Ministry of Education (MoE) could ensure that the innovation is given its initial implementation momentum and provide teachers with the required motivation to use it. However, such mandates should be accompanied by clear guidelines so that teachers are not only aware of their expectations but are also held accountable for the use or nonuse of the innovation. These mandates could be enforced internally within the school structure by head teachers or department heads or externally by education method advisors (EMAs) who could use the implementation of TALULAR as one of the criteria for evaluating teachers in schools for promotional decisions. Second, TALULAR can best be used when considered as a complement to the existing, conventional teaching and learning resources. Some teachers may have limited time for locating, creating, or designing and developing materials and other instructional resources needed. Therefore, to facilitate teachers’ use of TALULAR in the classroom and address their time limitation concerns, the MoE should ensure that basic teaching and learning resources are made available. Undeniably, resources such as chemicals and other equipment (ammeters, voltmeters, microscopes, oscilloscopes, etc) can not be improvised or “talularized” and should be made available in schools. The need for such resources calls for the government’s increased educational financing to carter for critical resources essential for providing quality science teaching and learning. This will allow schools to prepare future scientists who can effectively deal with the scientific and technological challenges of our society and competitively participate in the global economy. It should also be noted that the industry could be part of the solution in addressing the shortage of resources in schools, and facilitating the implementation of TALULAR. The MoE could involve local manufacturing industries to produce inexpensive but usable materials, such as calibrated plastic beakers, cylinders, and pipettes, for teaching and learning science. Third, the government should provide
adequate human and financial resources so that comprehensive and extensive TALULAR training workshops are conducted for all teachers. Findings for this study have revealed that about half of the teachers had not yet attended any TALULAR-related training. The importance of training in innovation implementation cannot be overemphasized. As clearly stated by Hull (1975), “the preparation of personnel in the use of an educational innovation is a prerequisite for successful initiation and implementation” (p.43). Besides training, the government could facilitate the acceptance and use of TALULAR by increasing awareness knowledge to targeted users through TV and radio broadcasts. Fourth, TALULAR training should be decentralized. It appears that currently, most of the training is done by the innovation specialist at MIE. To ensure that such training workshops are cost-effective and teachers receive ongoing and onsite support, more TALULAR specialists should be trained and deployed in each districts or school clusters across the country. These specialists will train teachers in their assigned locations and ensure that they receive ongoing support in their implementation efforts. Fifth, findings revealed that teachers attached great value to completing syllabi within their time constraints and ensuring that students were adequately prepared for national examinations. Undeniably, this influences their classroom practices and implies that any change efforts will not be successful if teachers do not perceive change as beneficial to their students in passing MANEB examinations. Therefore, it is suggested that appropriate mechanisms be put in place so that public examinations can be used to promote classroom instructional reform.

*Change agents or teacher trainers*

Findings of this study could also inform those involved in training teachers in the use of TALULAR. Here, five implications for practice are identified. First, teacher training opportunities need to be extended to all teachers if they are to implement the innovation.
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Training attendance emerged as an important determinant of TALULAR implementation. In addition, this study found that one of the major concerns teachers had related to TALULAR implementation was the lack of training opportunities. In fact, there is empirical evidence that teacher training is a major determinant of successful innovation implementation (Kirkgoz, 2008; McCormick et al., 1995; Stokes et al., 2000). These findings suggest the need to ensure that both in-service and pre-service teachers are adequately trained so that they have the essential technical skills, and pedagogical content knowledge and skills, to implement the innovation. Although technical skills and knowledge are important, emphasis on how the innovation fits with science pedagogy is even more important to enable teachers to use it effectively. Therefore, teachers should be given opportunities to observe examples of simple but successful science lessons with TALULAR so that they can see how such skills and knowledge could be applied in their own situations. According to Bandura (1986), vicarious experience is fundamental to observational learning, where potential users can develop not only a greater self-efficacy but also a greater sense of the innovation’s usability. In addition, when end-users have a higher self-efficacy associated with the innovation, the greater the likelihood that they will perceive it as easy to use (Venkatesh & Davis, 1996). In order for teachers to implement new ideas, their values need to be consistent with the demands of the innovation. As clearly recommended by Kirgoz (2008), “trainers need to be encouraged to give sufficient consideration to teachers’ existing beliefs, behaviors and classroom context in order to achieve harmony between these and new ideas to be introduced” (p.1861). Therefore, if teachers’ beliefs are a stumbling block to accepting TALULAR, then one of the goals of training should be to alter such beliefs so that they align with the innovation in order to facilitate its acceptance and usage. Second, consistent with the finding of this study where relative advantage was the strongest single predictor of TALULAR
implementation, the benefits or usefulness of the innovation should be communicated to teachers during professional development programs or training workshops. Agarwal et al. (1997) contended that organizational members will continue to use the innovation only if they are able to see its actual benefits clearly. Therefore, as pointed out already, it is more important for teachers to practically observe how simple lessons with TALULAR can be planned, executed, and evaluated. In cases where the short-term benefits of TALULAR can be realized, such benefits should be pointed out in order to motivate teachers to use the innovation.

Third, the training of TALULAR should be subject-specific. This will allow more in-depth collaborative explorations of both the innovation capabilities and limitations, and how specific science topics suggested by teachers could be taught using the innovation. For this to be possible, training participants should be actively involved in the learning process by participating in hands-on activities. As stated by Hull (1975), “the use of ‘hands on’ activities in a workshop setting are very useful to those who have to make the innovation work” (p.48).

Fourth, if training is organized for head teachers or department heads with the goal of preparing them to train others in their respective schools, it would be helpful to produce a resource book or a users’ guide as the end product of training. Such a resource book could be used as a general reference for teaching with TALULAR and as a guide for future training workshops. It is also important that this resource book should contain practical examples of resources and clear illustrations of how best they could be used for teaching and learning.

Fifth, the study finding in which observability of the use of the innovation by others was the second most important predictor of TALULAR implementation, suggests the need for change agents to ensure that opinion leaders support and model the use of the innovation within their social systems so that others who are still skeptical about the benefits and impact of using the
innovation could be influenced to use it. Diffusion research suggests that individuals who are perceived to have social accessibility, technical competence, and conform to social norms play a crucial role in ensuring innovation acceptance and usage among potential adopters in the social system (Rogers, 2003). Therefore, early involvement of carefully selected teachers who could be sources of information and advice to others about TALULAR innovation is essential to ensuring a successful diffusion campaign. As observed by Hull (1975), opinion leaders’ “advocacy allows informal communication channels to be used in installing the innovation” (p.45). In other words, potential adopters will be influenced to use the innovation due to internal pressure from their peers’ use of the innovation. This is consistent with empirical evidence, which suggests that when more potential users see more of their peers use the innovation (others’ use) the less they will think it is voluntary, and the more they will see it as advantageous and easy to use (Compeau et al., 2007).

**Teachers**

It is believed that findings in this study could also inform teachers’ practices. Three implications for practice are suggested. First, teachers’ concern that some resources that could help them in the use of TALULAR are unavailable, especially during certain seasons, suggests the need for teachers to plan what and how to teach well in advance. For instance, if teachers want students to explore and identify crop pests and diseases in the field, then it may be important for such lesson activities to be carried out during the planting season when crops are available in the field. Second, the difficulties faced by teachers in designing and developing resources for teaching and learning science can best be resolved through collaborative efforts among teachers. Teachers should view the lack of teaching and learning resources in schools as a shared problem and recognize that shared problem-solving strategies could be more effective. As
teachers work together, they could also develop and share resources that could be used by more than one teacher to teach various subject content areas. Third, teachers who are challenged by the demands of technical skills and knowledge and/or pedagogical approaches associated with the use of the innovation should be proactive in learning from their peers. They can deliberately observe how their peers select, design, and develop resources for teaching and learning or request to observe their classroom lessons with TALULAR.

Limitations

First and foremost, the strengths of this study include: (a) the sizable response rate of 77%, (b) the sampling procedure employed that ensured the participation of a more representative sample of public secondary school science teachers in the northern region of Malawi, and (c) measures that have sufficient validity information, and only data from perceived innovation constructs that had acceptable internal consistency reliability ($\alpha \geq .70$) were used in estimating regression models.

However, this study has some limitations that need to be recognized when interpreting the results. First, a small amount of variance in implementation was accounted for by the innovation factors. This could be due to the relevant perceived innovation characteristics (compatibility with prior experience and voluntariness of use) that were excluded in running the models due to their low internal consistency reliabilities. In addition, it may suggest that perhaps other social and contextual variables not captured in this study may better account for variance in implementation of TALULAR. Second, even though two items were used to collect data on the implementation of TALULAR, only data from a single item were used in the actual analysis. Perhaps designing multiple items as measures of implementation could have been desirable. Third, cross-sectional data were used in this research. Conceivably, longitudinal data may be
more useful in understanding other factors that would influence teachers’ continued use of the innovation over time. Fourth, this research should not be regarded as an experimental investigation, as neither random assignment nor variable manipulation was done. Therefore, only correlational inferences are meaningful and any causal inferences are unwarranted. In addition, any policy implications suggested herein need to be interpreted with caution.

Recommendations for further research

This section suggests avenues for further research that could be considered. These recommendations for further research spring from considerations of the study findings and their limitations. First, future studies can gather longitudinal data to examine the causal and correlational relationships among factors important in the diffusion of TALULAR. As observed by Hull (1975), “conditions in the school system which influence the acceptability of the innovation usually are different in the initial stages of implementation than in later stages” (p.46). Second, although the accounted variance in implementation of TALULAR was statistically significant, it is relatively lower for practical purposes. Therefore, further research might reassess the perceived characteristics of using innovations, including those that were excluded in estimating the regression models due to low reliabilities. In addition, other factors (both social and contextual) that might be relevant to the implementation of TALULAR should be examined. Third, the prediction equations generated in this study have not been cross-validated. Therefore, further research could collect separate data from different samples from the population of secondary school science teachers to evaluate the stability or the extent of shrinkage associated with these prediction models. Fourth, this study did not examine how effectively science teachers implemented the innovation in the classroom. Future research could, therefore, examine the extent to which teachers are effectively implementing the innovation as expected by policy...
makers or curriculum planners. Data important for such investigations could be collected through the use of classroom lesson observations and/or interviews with teachers. Fifth, findings of this study suggest that implementation involves the interplay of several variables, and such variables could have mediation and suppression effects on one another. Future research could, therefore, investigate causal models and the existence of any variable mediations or suppressions. Sixth, this study only looked at factors important for the implementation of TALULAR at one point in time. A comparative examination of factors important for predicting the current usage of TALULAR and those that would be important for predicting future intentions to use the innovation could be worthwhile.
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References


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Appendix A: IRB approval certificate

DATE: January 24, 2008

MEMORANDUM

TO: John K. Burton
Simeon Gwayi

FROM: Carmen Green


I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status. Approval is granted effective as of January 24, 2008.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.

2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File
Appendix B: Permission to conduct study from the Ministry of Education in Malawi

Ref. No. C31/1/1

17th June, 2008

FROM: THE SECRETARY FOR EDUCATION, SCIENCE AND TECHNOLOGY, PRIVATE BAG 238, LILONGWE 3.

TO: THE EDUCATION DIVISION NORTH, P.O. BOX 133, MZUZU

PERMISSION TO CONDUCT RESEARCH IN NORTHERN EDUCATION DIVISION

I am pleased to inform you that the Ministry of Education, Science and Technology has granted Mr. Simeon Gwayi to conduct research work in the Northern Education Division Secondary Schools.

Mr. Simeon Gwayi is a bona fide Malawian Lecturer at Mzuzu University currently studying in Virginia, U.S.A.

He is authorized to interview science teachers (Physical Science, Biology and Agriculture) in Community Day Secondary School, (CDSS) and Conventional Secondary Schools.

By copy of this letter, the Education Division Manager (NED) is informed to allow him research to be conducted in the division.

O.B.E Maganga
For: SECRETARY FOR EDUCATION, SCIENCE AND TECHNOLOGY
Appendix C: Permission to adapt instrument for measuring perceptions of using innovations

Dear Simeon,

I'm attaching the final section of the questionnaire you requested. We are happy to have you use the instrument we developed.

 Regards,

Debbie
Appendix D: Survey Instrument

Questionnaire for science teachers on the use of TALULAR as a teaching tool

Introduction
The objective of this questionnaire is to gather information that will help in understanding how TALULAR is used and perceived by secondary school science teachers in the northern region of Malawi. Permission to conduct this study with secondary school teachers has been granted by the Secretary of Education, Ministry of Education Science & Technology, and the Education Division Manager, North. Your participation and honest responses to the questions are very important for this survey to reflect the reality of issues regarding TALULAR idea or innovation. Any information you provide will be kept confidential, and study findings will be used for research purposes only. Do not indicate your name on the questionnaire. You will need to set aside about 25-35 minutes to complete this questionnaire. You will also need to have access to your time-table, records on the number of students and books for the science classes and forms you teach.

Part I
Information about teaching subjects and usage of TALULAR
In this part of the questionnaire you are asked to provide information about subjects you teach, and your use of TALULAR in teaching these subjects. Remember that the term TALULAR stands for Teaching And Learning Using Locally Available Resources.

Instructions: Please indicate your answers by either ticking the appropriate box or writing on the space provided.

1. Which of the following MSCE and/or JCE subjects do you teach? (please tick all MSCE & JCE subjects that you teach only)
   - MSCE
     - [ ] Physical Science
     - [ ] Biology
     - [ ] Agriculture
   - JCE
     - [ ] Physical Science
     - [ ] Biology
     - [ ] Agriculture

2. Do you think there is a need for using TALULAR in teaching your subjects at your school?
   - [ ] No
   - [ ] Yes

   Briefly explain your answer. __________________________________________________________

3. The ministry of education started encouraging teachers to use TALULAR around 1997.
   (a) Have you accepted the TALULAR idea? [ ] Yes [ ] No
   (b) Do you use TALULAR in your teaching?
     - [ ] Yes (if Yes, go to question # 4)
     - [ ] No (if No, go to question # 5)

4. If you answered Yes to question 3(a) above, when did you make this decision to accept or adopt TALULAR? Year________

   Instructions: For questions 5-6, please tick only one option in the appropriate box that best describes the frequency with which you use TALULAR in teaching ALL the subject(s) you selected in question 1 above.

5. On average, how many times a day do you use TALULAR in your teaching? (tick one box only)
   - [ ] Do not use at all
   - [ ] 3 times a day
   - [ ] More than 4 times a day
   - [ ] 2 times a day
   - [ ] Once a day
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6. On average, how many times in a week do you use TALULAR in your teaching? (tick one box only)
   [ ] Do not use at all
   [ ] 1-5 times in a week
   [ ] 6-10 times in a week
   [ ] 11-15 times in a week
   [ ] More than 15 times in a week

Part II

Perceived Characteristics of using TALULAR Innovation

This part of the questionnaire asks you about your perceptions or observations related to using TALULAR in your teaching. You will be asked to indicate the level of your agreement or disagreement with a number of statements. Some questions have been repeated on purpose, please answer ALL questions.

Instructions: For each statement, please circle only one answer on the column to the right that best describes how you personally feel about using TALULAR. The answers indicated by letters SD, D, N, A, SA indicate your level of agreement or disagreement with each statement.

Meaning of each letter symbol:
SD = Strongly Disagree;   A = Agree;   N = Neutral or Not Sure;   D = Disagree;   SA = Strongly Agree

1. Using TALULAR enables me to accomplish tasks more quickly.
   SD  D  N  A  SA
2. The use of TALULAR fits well with what I have been doing before.
   SD  D  N  A  SA
3. TALULAR provides capabilities or potentials that are in line with my Values (or beliefs).
   SD  D  N  A  SA
4. I believe that TALULAR is very involving to use.
   SD  D  N  A  SA
5. Several of my fellow teachers in this school use TALULAR.
   SD  D  N  A  SA
6. I would find it easy to tell others about the results of using TALULAR.
   SD  D  N  A  SA
7. It is hard to see the results of using TALULAR.
   SD  D  N  A  SA
8. I have had many opportunities to try out TALULAR.
   SD  D  N  A  SA
9. My superiors expect me to use TALULAR.
   SD  D  N  A  SA
10. Using TALULAR improves my image within the school.
    SD  D  N  A  SA
11. Using TALULAR improves the quality of work I do.
    SD  D  N  A  SA
12. Using TALULAR was a new experience for me.
    SD  D  N  A  SA
13. Using TALULAR is appropriate for a person with my values or beliefs regarding the role of resources in education.
    SD  D  N  A  SA
14. It is easy for me to remember how to perform tasks associated with using TALULAR.
    SD  D  N  A  SA
15. Several of my fellow teachers in other schools use TALULAR.
    SD  D  N  A  SA
16. Explaining to other teachers the advantages and disadvantages of using TALULAR would be easy.
    SD  D  N  A  SA
17. The effects of using TALULAR can be readily assessed.
    SD  D  N  A  SA
18. I know where I can go to satisfactorily try out various uses of TALULAR.
    SD  D  N  A  SA
19. Using TALULAR is optional in my job.
    SD  D  N  A  SA
20. Because of my use of TALULAR, others in my school see me as a more important employee.
    SD  D  N  A  SA
21. Using TALULAR makes it easier to do my job.
    SD  D  N  A  SA
22. Using TALULAR was similar to everything that I had done before.
    SD  D  N  A  SA
23. My values or beliefs are in conflict with the use of TALULAR.
    SD  D  N  A  SA
24. I believe that it is easy to get TALULAR to do what I want it to do.
    SD  D  N  A  SA
25. Teachers in my department use TALULAR.
    SD  D  N  A  SA
26. I think that I could very easily demonstrate the results of using TALULAR.
    SD  D  N  A  SA
27. It is easy to determine the impact of TALULAR. SD D N A SA
28. I am not sure where I can go to satisfactorily try out TALULAR. SD D N A SA
29. The decision to use TALULAR is entirely up to me. SD D N A SA
30. In my school, teachers gain respect by using TALULAR. SD D N A SA
31. Using TALULAR improves my job performance. SD D N A SA
32. I have adequate experience when it comes to using TALULAR. SD D N A SA
33. Using TALULAR is completely consistent with my values or beliefs. SD D N A SA
34. Overall, I believe that TALULAR is easy to use. SD D N A SA
35. In my school, one is aware of many teachers using TALULAR. SD D N A SA
36. I believe I could communicate to others the consequences of using TALULAR. SD D N A SA
37. The results of using TALULAR are apparent to me. SD D N A SA
38. TALULAR resources were available to me to test them adequately. SD D N A SA
39. The use of TALULAR is mandatory in my job. SD D N A SA
40. Because of my use of TALULAR, I see myself as a more valuable employee. SD D N A SA
41. Overall, I find using TALULAR to be advantageous in my job. SD D N A SA
42. Using TALULAR fits well with the knowledge and skills I have. SD D N A SA
43. Using TALULAR fits well with my beliefs about teaching and learning. SD D N A SA
44. Learning to use TALULAR is easy for me SD D N A SA
45. Many of my friends use TALULAR. SD D N A SA
46. Benefits from using TALULAR can be directly attributed to it. SD D N A SA
47. I had adequate opportunities to use TALULAR on a trial basis long enough to see what it could do. SD D N A SA
48. I am required to use TALULAR in performing my job. SD D N A SA
49. Using TALULAR improves my status in the school. SD D N A SA
50. Using TALULAR reduces my effectiveness on the job. SD D N A SA
51. TALULAR is user friendly. SD D N A SA
52. I have seen other teachers using TALULAR in my school. SD D N A SA
53. The real advantages of using TALULAR are not hard to prove. SD D N A SA
54. I had access to TALULAR for periods long enough to try it out. SD D N A SA
55. My bosses do not require me to use TALULAR. SD D N A SA
56. Using TALULAR gives me greater control over my work. SD D N A SA
57. It is easy to learn how to use TALULAR appropriately. SD D N A SA
58. Using TALULAR increases my productivity. SD D N A SA
59. Creating or designing and developing my own TALULAR is quite an easy task. SD D N A SA
60. Using TALULAR for teaching is cheaper. SD D N A SA
61. TALULAR resources are locally available in my environment. SD D N A SA

Part III
Participant and school information

Please note that the information gathered from you will be treated confidentially, and only group responses will be reported in the study.

1. What is your gender? (tick one box only)
   [   ] Male  [   ] Female
2. What is your age in years? (Tick one box only)
   [   ] 20-25  [   ] 26-30  [   ] 31-35  [   ] 36-40  [   ] 41-45
   [   ] 46-50  [   ] 51-55  [   ] 56-60  [   ] More than 60
3. What is your highest educational qualification? (tick one box only)
   [   ] JCE  [   ] Bachelor’s degree
   [   ] MSCE  [   ] Master’s
   [   ] Diploma  [   ] Other (specify) ____________
4. When were you first employed as a teacher? Year _______
Perceptions of Innovations as Predictors of TALULAR Implementation

5. For how long have you been a full-time teacher? (tick one box only)
   [ ] 0-3 years       [ ] 11-14 years
   [ ] 4-6 years       [ ] 15-20 years
   [ ] 7-10 years      [ ] More than 20 years

6. For how long have you been teaching at this school? ____________ years

7. What is your position at this school? (Tick one)
   [ ] teacher
   [ ] head teacher

8. What is the type of the school where you teach now? (Tick one)
   [ ] CDSS (Community Day Secondary School)
   [ ] Conventional Secondary School

9. In which subject(s) are you specialized to teach? _______________________________________________

10. In the table below, put a tick against the subject(s) you teach only. Then indicate the total number of periods you teach per week in the appropriate column for MSCE & JCE.

    (Note: The ‘total number of periods’ should include both teaching and laboratory or practical periods. Make sure you add all periods for all the forms you teach at MSCE & JCE levels)

<table>
<thead>
<tr>
<th>Tick subject(s) you teach</th>
<th>Name of subject</th>
<th>MSCE</th>
<th>JCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total # of periods you teach per week for forms 3 &amp; 4.</td>
<td>Total # of periods you teach per week for forms 1 &amp; 2.</td>
</tr>
<tr>
<td>Physical Science</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. In the tables below, indicate the total number of students taking each subject you teach, and the approximate total number of recommended textbooks available at your school.

    MSCE

<table>
<thead>
<tr>
<th>Name of subject(s) you teach (tick all that apply)</th>
<th>Total # of all students in forms 3 &amp; 4 taking the subject</th>
<th>Total number of recommended books available</th>
</tr>
</thead>
<tbody>
<tr>
<td>P/science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

    JCE

<table>
<thead>
<tr>
<th>Name of subject(s) you teach (tick all that apply)</th>
<th>Total # of all students in forms 1 &amp; 2 taking the subject</th>
<th>Total number of recommended books available</th>
</tr>
</thead>
<tbody>
<tr>
<td>P/science</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. The awareness campaign for TALULAR began around 1997. When did you first learn about the existence of TALULAR innovation? (tick one box only)
    [ ] 1997    [ ] 2001    [ ] 2005
    [ ] 2000    [ ] 2004    [ ] 2008

13. From what source did you learn about TALULAR? (tick all that apply)
    [ ] a. From informal interactions with fellow teacher(s)
    [ ] b. From a training workshop done by fellow teacher (s)
    [ ] c. From training workshop(s) by the head teacher

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Perceptions of Innovations as Predictors of TALULAR Implementation

[ ] d. During a TALULAR training workshop by an TALULAR expert
[ ] e. From my lecturers or tutors at university or college
[ ] f. From the subject syllabus
[ ] g. On the radio
[ ] h. On Television (TV)
[ ] i. From teachers’ guides
[ ] j. From TALULAR resource book
[ ] k. Other (specify) ____________________________

14. Amongst the sources of information indicated in question number 13 above, which source (s) were most beneficial to you in learning about TALULAR?

15. Which source of information, from question number 13 above, was most beneficial to you in helping you learn how to use TALULAR in teaching?

16. Have you ever attended any TALULAR training or workshop since the introduction of TALULAR?

[ ] Yes (if yes, go to question 17)
[ ] No (if no, go to question # 19)

17. If you answered yes to question 16 above, how many times have you undergone TALULAR training? [ ] Once [ ] 2-3 times [ ] 4-5 times [ ] More than 5 times

18. On average, how many hours have you spent in TALULAR-related training(s) or Workshop(s) over the past years (tick one box only)

[ ] 0-1 hour [ ] 8-10 hours [ ] 17-19 hours
[ ] 2-4 hours [ ] 11-13 hours [ ] More than 20 hours
[ ] 5-7 hours [ ] 14-16 hours

19. Are there any benefits of using TALULAR in your teaching that you have noted so far?

[ ] Yes [ ] No (if no, go to question # 20)

If yes, briefly describe such benefit(s) in the space provided below:
______________________________________________________________________________

20. Are there any concerns you have regarding the use of TALULAR in teaching?

[ ] Yes [ ] No (if no, go to question 21)

If you answered yes, briefly describe your concern(s) in the space provided below:
______________________________________________________________________________

21. Is there anything related to TALULAR that you think should be improved?

[ ] Yes [ ] No (if no, go to question 22)

If yes, explain your answer in the space below:
______________________________________________________________________________

22. What major problem(s), if any, do you encounter in your profession as a teacher in the following categories?

(i) Teaching materials or resources:
______________________________________________________________________________

(ii) Relevant text books:
______________________________________________________________________________

THIS IS THE END OF THE QUESTIONNAIRE. THANK YOU SO MUCH FOR YOUR TIME AND INPUT. PLEASE RETURN THE COMPLETED QUESTIONNAIRE TO THE HEAD TEACHER OR THE RESEARCHER.
Perceptions of Innovations as Predictors of TALULAR Implementation

Appendix E: Survey items per construct and their source

<table>
<thead>
<tr>
<th>Item code</th>
<th>Item reverse scored</th>
<th>Item Source</th>
<th>Item Deleted</th>
<th>Original Item Wording</th>
<th>Wording of Item Used</th>
<th>Item # in Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAD1</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system enables me to accomplish tasks more quickly</td>
<td>Using TALULAR enables me to accomplish tasks more quickly</td>
<td>1</td>
</tr>
<tr>
<td>RAD2</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system improves the quality of work I do.</td>
<td>Using TALULAR improves the quality of work I do.</td>
<td>11</td>
</tr>
<tr>
<td>RAD3</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system makes it easier to do my job.</td>
<td>Using TALULAR makes it easier to do my job.</td>
<td>21</td>
</tr>
<tr>
<td>RAD4</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system improves my job performance.</td>
<td>Using TALULAR improves my job performance.</td>
<td>31</td>
</tr>
<tr>
<td>RAD5</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Overall, I find using the hospital computer system to be advantageous in performing my job.</td>
<td>Overall, I find using TALULAR to be advantageous in performing my job.</td>
<td>41</td>
</tr>
<tr>
<td>RAD6</td>
<td>R C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system reduces my effectiveness on the job.</td>
<td>Using TALULAR reduces my effectiveness on the job.</td>
<td>50</td>
</tr>
<tr>
<td>RAD7</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system gives me greater control over my work.</td>
<td>Using TALULAR gives me greater control over my work.</td>
<td>56</td>
</tr>
<tr>
<td>RAD8</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system increases my productivity</td>
<td>Using TALULAR increases my productivity.</td>
<td>58</td>
</tr>
<tr>
<td>RAD9</td>
<td>New item</td>
<td></td>
<td></td>
<td>The use of the hospital computer system is compatible with my past experience.</td>
<td>The use of TALULAR fits well with what I have been doing before</td>
<td>2</td>
</tr>
<tr>
<td>RAD10</td>
<td>New item</td>
<td></td>
<td></td>
<td>The use of the hospital computer system is compatible with my past experience.</td>
<td>The use of TALULAR fits well with what I have been doing before</td>
<td>61</td>
</tr>
<tr>
<td>CPE1</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system was a new experience for me.</td>
<td>Using TALULAR was a new experience for me</td>
<td>12</td>
</tr>
<tr>
<td>CPE2</td>
<td>R C.,M.,H.</td>
<td>X</td>
<td></td>
<td>Using the hospital computer system was a new experience for me.</td>
<td>Using TALULAR was a new experience for me</td>
<td>12</td>
</tr>
<tr>
<td>CPE3</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Using the hospital computer system was different from everything that I’d done before.</td>
<td>Using TALULAR was similar to everything that I had done before</td>
<td>22</td>
</tr>
<tr>
<td>CPE4</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>I lack experience when it comes to things like using the hospital computer system.</td>
<td>I have adequate experience when it comes to using TALULAR</td>
<td>32</td>
</tr>
<tr>
<td>CPE5</td>
<td>New item</td>
<td></td>
<td></td>
<td>Using the hospital computer system was a new experience for me.</td>
<td>Using TALULAR was a new experience for me</td>
<td>42</td>
</tr>
</tbody>
</table>

**Perceptions of Innovations as Predictors of TALULAR Implementation**

### Appendix E (Continued)

<table>
<thead>
<tr>
<th>Item code</th>
<th>Item reverse scored</th>
<th>Item Source</th>
<th>Item Deleted</th>
<th>Original Item Wording</th>
<th>Wording of Item Used</th>
<th>Item # in Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>CWV1</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>The hospital compute system provides capabilities that run counter to my values</td>
<td>TALULAR provides capabilities or potentials that are in line with my values (or believes).</td>
<td>3</td>
</tr>
<tr>
<td>CWV2</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>Using the hospital compute system is inappropriate for a person with my values or beliefs regarding the role of resources in education.</td>
<td>Using TALULAR is appropriate for a person with my values or beliefs regarding the role of resources in education.</td>
<td>13</td>
</tr>
<tr>
<td>CWV3</td>
<td>R</td>
<td>C.,M.,H.</td>
<td>X</td>
<td>My values or beliefs are in conflict with the use of the hospital compute system.</td>
<td>My values or beliefs are in conflict with the use of TALULAR.</td>
<td>23</td>
</tr>
<tr>
<td>CWV4</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>Using the hospital compute system is completely consistent with my values.</td>
<td>Using TALULAR is completely consistent with my values or beliefs.</td>
<td>33</td>
</tr>
<tr>
<td>CWV5</td>
<td>New item</td>
<td></td>
<td></td>
<td>Using the hospital compute system fits well with my beliefs about teaching and learning.</td>
<td>Using TALULAR fits well with my beliefs about teaching and learning.</td>
<td>43</td>
</tr>
<tr>
<td>EOU1</td>
<td>R</td>
<td>C.,M.,H.</td>
<td>X</td>
<td>I believe that the hospital compute system is cumbersome to use</td>
<td>I believe that TALULAR is very involving to use.</td>
<td>4</td>
</tr>
<tr>
<td>EOU2</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>It is easy for me to remember how to perform tasks associated with using the hospital compute system</td>
<td>It is easy for me to remember how to perform tasks associated with using TALULAR.</td>
<td>14</td>
</tr>
<tr>
<td>EOU3</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>I believe that it is easy to get the hospital compute system to do what I want it to do.</td>
<td>I believe that it is easy to get TALULAR to do what I want it to do.</td>
<td>24</td>
</tr>
<tr>
<td>EOU4</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>Overall, I believe that the hospital compute system is easy to use.</td>
<td>Overall, I believe that TALULAR is easy to use.</td>
<td>34</td>
</tr>
<tr>
<td>EOU5</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>Learning to use the hospital compute system was easy for me</td>
<td>Learning to use TALULAR is easy for me.</td>
<td>44</td>
</tr>
<tr>
<td>EOU6</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>The hospital compute system is user friendly.</td>
<td>TALULAR is user friendly.</td>
<td>51</td>
</tr>
<tr>
<td>EOU7</td>
<td>New item</td>
<td></td>
<td></td>
<td>It is easy to learn how to use TALULAR appropriately.</td>
<td></td>
<td>57</td>
</tr>
</tbody>
</table>

*Note. Abbreviations used: RAD = Relative advantage, CPE = Compatibility with prior experience, CWV = Compatibility with values, EOU = Ease of Use, OOU = Others’ use, OCM = Communicability, OMS = Measurability, TRI = Trialability, VOL = Voluntariness, IMA = Image. X = Item deleted after item analysis using internal consistency reliability. R = Reverse scored items used in survey. C, M, H. = Campeau, Meister & Higgins (2007).*
Perceptions of Innovations as Predictors of TALULAR Implementation

Appendix E (Continued)

<table>
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<tr>
<th>Item code</th>
<th>Item reverse scored</th>
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<th>Item Deleted</th>
<th>Original Item Wording</th>
<th>Wording of Item Used</th>
<th>Item # in Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOU8</td>
<td>New item</td>
<td></td>
<td></td>
<td>Creating or designing and developing my own TALULAR is quite an easy task.</td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>OOU1</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Several of my fellow teachers in this school use TALULAR.</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>OOU2</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Several of my fellow teachers in other schools use TALULAR.</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>OOU3</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Teachers in my department use TALULAR.</td>
<td></td>
<td>25</td>
</tr>
<tr>
<td>OOU4</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>In my school, one is aware of many teachers using TALULAR.</td>
<td></td>
<td>35</td>
</tr>
<tr>
<td>OOU5</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Many of my friends use TALULAR.</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>OOU6</td>
<td>M&amp;B</td>
<td></td>
<td></td>
<td>I have seen other teachers using TALULAR in my school.</td>
<td></td>
<td>52</td>
</tr>
<tr>
<td>OCM1</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>I would find it easy to tell others about the results of using TALULAR.</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>OCM2</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>Explaining to other teachers the advantages and disadvantages of using TALULAR would be easy.</td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>OCM3</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>I think that I could very easily demonstrate the results of using TALULAR.</td>
<td></td>
<td>26</td>
</tr>
<tr>
<td>OCM4</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>I believe I could communicate to others the consequences of using TALULAR.</td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>OMS1</td>
<td>R</td>
<td>C.,M.,H.</td>
<td></td>
<td>It is hard to see the results of using TALULAR.</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>OMS2</td>
<td>C.,M.,H.</td>
<td></td>
<td></td>
<td>The effects of using TALULAR can be readily assessed.</td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

Perceptions of Innovations as Predictors of TALULAR Implementation

### Appendix E (Continued)

<table>
<thead>
<tr>
<th>Item code</th>
<th>Item reverse scored</th>
<th>Item Source</th>
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<th>Original Item Wording</th>
<th>Wording of Item Used</th>
<th>Item # in Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMS3</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>It is easy to determine the impact of the hospital computer system.</td>
<td>It is easy to determine the impact of TALULAR</td>
<td>27</td>
</tr>
<tr>
<td>OMS4</td>
<td></td>
<td>M&amp;B</td>
<td></td>
<td>The results of using a PWS are apparent to me.</td>
<td>The results of using TALULAR are apparent to me.</td>
<td>37</td>
</tr>
<tr>
<td>OMS5</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>Benefits from using [the innovation] can be directly attributed to it.</td>
<td>Benefits from using TALULAR can be directly attributed to it.</td>
<td>46</td>
</tr>
<tr>
<td>OMS6</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>The real advantages of using [the innovation] are hard to prove.</td>
<td>The real advantages of using TALULAR are not hard to prove.</td>
<td>53</td>
</tr>
<tr>
<td>TRI1</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>I have had many opportunities to try out the hospital computer system.</td>
<td>I have had many opportunities to try out TALULAR</td>
<td>8</td>
</tr>
<tr>
<td>TRI2</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>I know where I can go to satisfactorily try out various uses of the hospital computer system.</td>
<td>I know where I can go to satisfactorily try out various uses of TALULAR</td>
<td>18</td>
</tr>
<tr>
<td>TRI3</td>
<td>R</td>
<td>C.,M.,H.</td>
<td></td>
<td>I am unsure as to where I can go to satisfactorily try out the hospital computer system.</td>
<td>I am not sure where I can go to satisfactorily try out TALULAR.</td>
<td>28</td>
</tr>
<tr>
<td>TRI4</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>The hospital computer system was available to me to test adequately.</td>
<td>TALULAR resources were available to me to test them adequately.</td>
<td>38</td>
</tr>
<tr>
<td>TRI5</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>I was permitted to use the hospital computer system on a trial basis long enough to see what it could do.</td>
<td>I had adequate opportunities to use TALULAR on a trial basis long enough to see what it could do.</td>
<td>47</td>
</tr>
<tr>
<td>TRI6</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>I had access to the hospital computer system for periods long enough to try it out.</td>
<td>I had access to TALULAR for periods long enough to try it out.</td>
<td>54</td>
</tr>
<tr>
<td>VOL1</td>
<td>R</td>
<td>M&amp;B</td>
<td></td>
<td>My superiors expect me to use a PWS.</td>
<td>My superiors expect me to use TALULAR.</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>My managers in my organization expect me to use the hospital computer system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOL2</td>
<td></td>
<td>C.,M.,H.</td>
<td></td>
<td>Although it might be helpful, using the hospital computer system is optional in my job.</td>
<td>Using TALULAR is optional in my job.</td>
<td>19</td>
</tr>
</tbody>
</table>

### Appendix E (Continued)

<table>
<thead>
<tr>
<th>Item code</th>
<th>Item reverse scored</th>
<th>Item Source</th>
<th>Item Deleted</th>
<th>Original Item Wording</th>
<th>Wording of Item Used</th>
<th>Item # in Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOL3</td>
<td></td>
<td>C.,M.,H</td>
<td>X</td>
<td>My decision to use the hospital computer system is entirely up to me.</td>
<td>The decision to use TALULAR is entirely up to me.</td>
<td>29</td>
</tr>
<tr>
<td>VOL4</td>
<td>R</td>
<td>C.,M.,H</td>
<td></td>
<td>The use of the hospital computer system is mandatory in my organization.</td>
<td>The use of TALULAR is mandatory in my job.</td>
<td>39</td>
</tr>
<tr>
<td>VOL5</td>
<td>R</td>
<td>C.,M.,H</td>
<td></td>
<td>My organization requires me to use the hospital computer system in performing my job.</td>
<td>I am required to use TALULAR in performing my job.</td>
<td>48</td>
</tr>
<tr>
<td>VOL6</td>
<td></td>
<td>M&amp;B</td>
<td></td>
<td>My boss does not require me to use a PWS.</td>
<td>My bosses do not require me to use TALULAR.</td>
<td>55</td>
</tr>
<tr>
<td>IMA1</td>
<td></td>
<td>C.,M.,H</td>
<td></td>
<td>Using the hospital computer system improves my image within the school.</td>
<td>Using TALULAR improves my image within the school.</td>
<td>10</td>
</tr>
<tr>
<td>IMA2</td>
<td></td>
<td>C.,M.,H</td>
<td></td>
<td>Because of my use of the hospital computer system, others in my school see me as a more important employee.</td>
<td>Because of my use of TALULAR, others in my school see me as a more important employee.</td>
<td>20</td>
</tr>
<tr>
<td>IMA3</td>
<td></td>
<td>C.,M.,H</td>
<td></td>
<td>In my organization, people gain prestige by using the hospital computer system.</td>
<td>In my school, teachers gain respect by using TALULAR.</td>
<td>30</td>
</tr>
<tr>
<td>IMA4</td>
<td></td>
<td>C.,M.,H</td>
<td></td>
<td>Because of my use of the hospital computer system, I see myself as a more important employee.</td>
<td>Because of my use of TALULAR, I see myself as a more valuable employee.</td>
<td>40</td>
</tr>
<tr>
<td>IMA5</td>
<td></td>
<td>M&amp;B</td>
<td></td>
<td>Using a PWS improves my image within the organization.</td>
<td>Using TALULAR improves my status in the school.</td>
<td>49</td>
</tr>
</tbody>
</table>

## Appendix F: Definitions of the perceived characteristics of innovation (PCI) constructs

<table>
<thead>
<tr>
<th>Construct (Abbreviation)</th>
<th>Construct definition</th>
<th>Survey items measuring construct</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Advantage (RAD)</td>
<td>The degree to which the innovation is perceived as being better than the other options – the comparison may be explicit (A is better than B) or implicit (A is better).</td>
<td>1, 11, 21, 31, 41, 50, 56, 58, 60, 61.</td>
</tr>
<tr>
<td>Compatibility with Prior Experience (CPE)</td>
<td>The degree to which the innovation is perceived as being consistent with prior experience of potential users.</td>
<td>2, 12, 22, 32, 42.</td>
</tr>
<tr>
<td>Compatibility with Values (CWV)</td>
<td>The degree to which the innovation is perceived as being consistent with the existing values of potential users.</td>
<td>3, 13, 23, 33, 43</td>
</tr>
<tr>
<td>Ease of Use (EOU)</td>
<td>The degree to which the innovation is perceived as being easy to use.</td>
<td>4, 14, 24, 34, 44, 51, 57, 59.</td>
</tr>
<tr>
<td>Others’ Use (OOU)</td>
<td>The degree to which potential users are aware of other people using the innovation.</td>
<td>5, 15, 25, 35, 45, 52.</td>
</tr>
<tr>
<td>Communicability (OCM)</td>
<td>The degree to which results of using the innovation can be easily communicated to others.</td>
<td>6, 16, 26, 36.</td>
</tr>
<tr>
<td>Measurability (OMS)</td>
<td>The degree to which the impact of the innovation can be assessed. In particular, the ability to clearly attribute the effects to the innovation.</td>
<td>7, 17, 27, 37, 46, 53.</td>
</tr>
<tr>
<td>Trialability (TRI)</td>
<td>The degree to which the innovation may be experimented with before adoption</td>
<td>8, 18, 28, 38, 47, 54.</td>
</tr>
<tr>
<td>Voluntariness (VOL)</td>
<td>The degree to which adoption of the innovation is viewed as a matter of personal choice, rather than external pressure</td>
<td>9, 19, 29, 39, 48, 55.</td>
</tr>
<tr>
<td>Image (IMA)</td>
<td>The degree to which using the innovation is perceived to enhance one’s image or status in the organization.</td>
<td>10, 20, 30, 40, 49.</td>
</tr>
</tbody>
</table>

*Note.* Adapted from Campeau et al. (2007). From prediction to explanation: Reconceptualizing and extending perceived characteristics of innovating. Journal of the Association for Information Systems, 8(8), 409-439.
Appendix G

This appendix consists of tables with summary information on respondents demographic and employment characteristics.

Table G1

*Distributions of teachers’ highest level of education by type of school*

<table>
<thead>
<tr>
<th>Highest level of education</th>
<th>Type of school</th>
<th>Total</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CDSS (n)</td>
<td>CSS (n)</td>
<td></td>
</tr>
<tr>
<td>MSCE</td>
<td>84</td>
<td>1</td>
<td>85</td>
</tr>
<tr>
<td>Diploma</td>
<td>56</td>
<td>43</td>
<td>99</td>
</tr>
<tr>
<td>Bachelor's</td>
<td>27</td>
<td>53</td>
<td>80</td>
</tr>
<tr>
<td>Masters</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>172</td>
<td>97</td>
<td>269</td>
</tr>
</tbody>
</table>

*Note: n = number of participants in each category*
Table G2

*Composition of teachers by teaching subject*

<table>
<thead>
<tr>
<th>Subject</th>
<th>n</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCE_P/Science</td>
<td>63</td>
<td>23.4</td>
</tr>
<tr>
<td>MSCE_Biology</td>
<td>91</td>
<td>33.8</td>
</tr>
<tr>
<td>MSCE_Agriculture</td>
<td>67</td>
<td>24.9</td>
</tr>
<tr>
<td>JCE_P/Science</td>
<td>88</td>
<td>32.7</td>
</tr>
<tr>
<td>JCE_Biology</td>
<td>106</td>
<td>39.4</td>
</tr>
<tr>
<td>JCE_Agriculture</td>
<td>71</td>
<td>26.4</td>
</tr>
</tbody>
</table>

*Note: N = 269. JCE denotes junior secondary school level (or junior high), & MSCE denotes senior secondary school level (or senior high school level).*

Table G3

*Teaching load (# of periods or 40 minute lessons per week)*

<table>
<thead>
<tr>
<th>No. of periods</th>
<th>n</th>
<th>Valid Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-5</td>
<td>46</td>
<td>18.5</td>
</tr>
<tr>
<td>6-9</td>
<td>77</td>
<td>30.9</td>
</tr>
<tr>
<td>10-13</td>
<td>59</td>
<td>23.7</td>
</tr>
<tr>
<td>14-17</td>
<td>26</td>
<td>10.4</td>
</tr>
<tr>
<td>18-21</td>
<td>28</td>
<td>11.3</td>
</tr>
<tr>
<td>≥22</td>
<td>13</td>
<td>5.2</td>
</tr>
<tr>
<td>Total</td>
<td>249</td>
<td>100</td>
</tr>
</tbody>
</table>

*Note. Min = 2, Max = 36, M = 10.74, SD = 6.14*
Table G4

*Distribution of teaching loads by school type*

<table>
<thead>
<tr>
<th>School type</th>
<th>2-3 periods</th>
<th>6-9 periods</th>
<th>10-13 periods</th>
<th>14-17 periods</th>
<th>18-21 periods</th>
<th>&gt;21 periods</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDSS</td>
<td>37</td>
<td>57</td>
<td>39</td>
<td>14</td>
<td>7</td>
<td>5</td>
<td>159</td>
</tr>
<tr>
<td>CSS</td>
<td>9</td>
<td>20</td>
<td>20</td>
<td>12</td>
<td>21</td>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>77</td>
<td>59</td>
<td>26</td>
<td>28</td>
<td>13</td>
<td>249</td>
</tr>
</tbody>
</table>

*Note:* CDSS: 2-13 periods (53.4%), 14-21 periods (8.4%), >21 periods (2.0%). CSS: 2-13 periods (19.7%), 14-21 periods (13.3%), >21 periods (3.2%).

Table G5

*Average number of textbooks and students in each subject and student to # of textbooks ratios*

<table>
<thead>
<tr>
<th>Subject</th>
<th>Average # of students</th>
<th>Average # of available textbooks</th>
<th>Students/textbook ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSCE_P/Science</td>
<td>92.58(61.32)</td>
<td>21.17(34.12)</td>
<td>4:1</td>
</tr>
<tr>
<td>MSCE_Biology</td>
<td>79.05(48.94)</td>
<td>15.36(22.47)</td>
<td>5:1</td>
</tr>
<tr>
<td>MSCE_Agriculture</td>
<td>73.81(65.31)</td>
<td>8.37(11.17)</td>
<td>9:1</td>
</tr>
<tr>
<td>JCE_P/Science</td>
<td>100.88(57.60)</td>
<td>19.88(42.21)</td>
<td>5:1</td>
</tr>
<tr>
<td>JCE_Biology</td>
<td>98.12(59.80)</td>
<td>13.74(24.99)</td>
<td>7:1</td>
</tr>
<tr>
<td>JCE_Agriculture</td>
<td>89.03(56.47)</td>
<td>9.70(16.85)</td>
<td>9:1</td>
</tr>
</tbody>
</table>

*Note:* Standard deviations (SDs) are in parenthesis, ( ). Average student/textbook ratio = 7:1. JCE denotes junior secondary school level, & MSCE denotes senior secondary school level.
Table G6

**Student to teacher ratios by school type**

<table>
<thead>
<tr>
<th>School type</th>
<th>Variable</th>
<th>n</th>
<th>Students/teacher ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDSS</td>
<td>Students</td>
<td>20668</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teachers</td>
<td>163</td>
<td>127:1</td>
</tr>
<tr>
<td>CSS</td>
<td>Students</td>
<td>17529</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teachers</td>
<td>90</td>
<td>195:1</td>
</tr>
</tbody>
</table>

*Note: Overall student to teacher ratio is 151:1 (i.e., 38197 students/263 teachers)*

Table G7

**Teachers’ responses regarding need for TALULAR, its adoption, and use.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Category</th>
<th>n</th>
<th>Valid percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Need</td>
<td>Yes</td>
<td>261</td>
<td>97.8</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>6</td>
<td>2.2</td>
</tr>
<tr>
<td>Adoption</td>
<td>Yes</td>
<td>262</td>
<td>98.5</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>4</td>
<td>1.5</td>
</tr>
<tr>
<td>Use</td>
<td>Yes</td>
<td>241</td>
<td>93.4</td>
</tr>
<tr>
<td></td>
<td>NO</td>
<td>17</td>
<td>6.6</td>
</tr>
</tbody>
</table>

*Note. Valid cases: Need (n = 267); Adoption (n = 266); Use (n = 258).*
Perceptions of Innovations as Predictors of TALULAR Implementation

Appendix H

This appendix consists of tables on means and standard deviations of perceived attributes of using TALULAR and level of implementation, and inter-correlations among perceived attributes.

Table H1

*Descriptive statistics: Perceptions of using TALULAR and level of implementation*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative Advantage</td>
<td>4.1386</td>
<td>.52789</td>
<td>265</td>
</tr>
<tr>
<td>Compatibility with Prior Experience</td>
<td>3.4987</td>
<td>.60158</td>
<td>265</td>
</tr>
<tr>
<td>Compatibility With Values</td>
<td>3.7201</td>
<td>.63587</td>
<td>265</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>3.7866</td>
<td>.58445</td>
<td>265</td>
</tr>
<tr>
<td>Others' Use</td>
<td>3.4507</td>
<td>.62363</td>
<td>265</td>
</tr>
<tr>
<td>Communicability</td>
<td>3.9223</td>
<td>.55710</td>
<td>265</td>
</tr>
<tr>
<td>Measurability</td>
<td>3.9069</td>
<td>.49047</td>
<td>265</td>
</tr>
<tr>
<td>Trialability</td>
<td>3.4699</td>
<td>.61587</td>
<td>265</td>
</tr>
<tr>
<td>Voluntariness</td>
<td>2.2185</td>
<td>.60388</td>
<td>265</td>
</tr>
<tr>
<td>Image</td>
<td>3.4206</td>
<td>.83025</td>
<td>265</td>
</tr>
<tr>
<td>Implementation</td>
<td>2.69</td>
<td>1.043</td>
<td>265</td>
</tr>
</tbody>
</table>
Table H2

Correlation matrix among the PCIs

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RAD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. CWV</td>
<td>.497</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. EOU</td>
<td>.672</td>
<td>.517</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. OOU</td>
<td>.363</td>
<td>.207</td>
<td>.395</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. OCM</td>
<td>.563</td>
<td>.478</td>
<td>.618</td>
<td>.399</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. OMS</td>
<td>.546</td>
<td>.471</td>
<td>.562</td>
<td>.360</td>
<td>.628</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. TRI</td>
<td>.473</td>
<td>.394</td>
<td>.553</td>
<td>.447</td>
<td>.584</td>
<td>.520</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. IMA</td>
<td>.533</td>
<td>.481</td>
<td>.454</td>
<td>.333</td>
<td>.520</td>
<td>.501</td>
<td>.496</td>
<td></td>
</tr>
</tbody>
</table>

Note: All correlations are significant at \( p = .01 \) (2-tailed). RAD = Relative advantage; CPE= Compatibility with prior experience; CWV = Compatibility with values, EOU = Ease of use; OOU = Others’ use; OCM= Communicability; OMS = Measurability, TRI =Trialability, VOL: Voluntariness, IMA=Image
Perceptions of Innovations as Predictors of TALULAR Implementation

Appendix I

This appendix consists of simultaneous regression output table for research question two, and bivariate correlations between perceptions of innovations and demographic and employment variables for question four.

Table I1

*Summary simultaneous regression results for 4 predictors after model revision*

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>.181</td>
<td>.514</td>
<td>.351</td>
<td>.726</td>
<td></td>
</tr>
<tr>
<td>Relative Advantage</td>
<td>.502**</td>
<td>.165</td>
<td>.254</td>
<td>3.035</td>
<td>.003</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>-.298*</td>
<td>.144</td>
<td>-.167</td>
<td>-2.068</td>
<td>.040</td>
</tr>
<tr>
<td>Others' Use</td>
<td>.260*</td>
<td>.108</td>
<td>.155</td>
<td>2.410</td>
<td>.017</td>
</tr>
<tr>
<td>Image</td>
<td>.194*</td>
<td>.088</td>
<td>.154</td>
<td>2.198</td>
<td>.029</td>
</tr>
</tbody>
</table>

*Note. For the revised model: $R^2 = .126$; Adjusted $R^2 = .112$, $F(4,260) = 9.346$, $p < .01$  For $B$’s: * $p < .05$, ** $p < .01$*

Table I2

*Inter-correlations between perceptions of innovations and demographic/employment variables*

<table>
<thead>
<tr>
<th>Variable</th>
<th>School type</th>
<th>Training attendance</th>
<th>Experience</th>
<th>Gender</th>
<th>Qualification</th>
<th>Length of training</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. RA</td>
<td>-.174**</td>
<td>.273**</td>
<td>.154*</td>
<td>.064</td>
<td>-.234**</td>
<td>.052</td>
</tr>
<tr>
<td>2. CWV</td>
<td>-.122*</td>
<td>.227**</td>
<td>.110</td>
<td>.085</td>
<td>-.075</td>
<td>.024</td>
</tr>
<tr>
<td>3. EOU</td>
<td>-.122*</td>
<td>.206**</td>
<td>.124*</td>
<td>.066</td>
<td>-.166**</td>
<td>-.007</td>
</tr>
</tbody>
</table>

* ** $p < .01$ (2-tailed)  * $p < .05$ (2-tailed)
Table I2 (Continued)

<table>
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<tr>
<th>Variable</th>
<th>School type</th>
<th>Training attendance</th>
<th>Experience</th>
<th>Gender</th>
<th>Qualification</th>
<th>Length of training</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. OOU</td>
<td>-.157**</td>
<td>.130*</td>
<td>.167**</td>
<td>.081</td>
<td>-.217**</td>
<td>-.021</td>
</tr>
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<td>5. OCM</td>
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<td>.293**</td>
<td>.086</td>
<td>.081</td>
<td>-.189**</td>
<td>-.018</td>
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<tr>
<td>6. OMS</td>
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<td>.153*</td>
<td>.041</td>
<td>.042</td>
<td>-.152*</td>
<td>.129</td>
</tr>
<tr>
<td>7. TRI</td>
<td>-.136*</td>
<td>.254**</td>
<td>.094</td>
<td>.035</td>
<td>-.140*</td>
<td>-.046</td>
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<td>8. IMA</td>
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<td>.279**</td>
<td>.108</td>
<td>.064</td>
<td>-.303**</td>
<td>.123</td>
</tr>
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</table>

**p < .01 (2-tailed)  *p < .05 (2-tailed)
Perceptions of Innovations as Predictors of TALULAR Implementation

Appendix J

This appendix consists of summative tables on Levene’s tests for t tests and ANOVA.

Table J1

*Results of Levene’s test for homogeneity of variance for gender, school type & training attendance.*

<table>
<thead>
<tr>
<th>Grouping variable</th>
<th>F</th>
<th>Sig.</th>
<th>df₁</th>
<th>df₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>.604</td>
<td>.438</td>
<td>263</td>
<td>59.052</td>
</tr>
<tr>
<td>School type</td>
<td>.791</td>
<td>.375</td>
<td>263</td>
<td>206.834</td>
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<tr>
<td>Training attendance</td>
<td>.064</td>
<td>.801</td>
<td>257</td>
<td>256.840</td>
</tr>
</tbody>
</table>

*Note.* Dependent variable = Level of implementation.  
\( df₁ = \) equal variance assumed; \( df₂ = \) unequal variance assumed

Table J2

*Results of Levene’s test for homogeneity of variance for level of education, experience and length of training*

<table>
<thead>
<tr>
<th>Variable</th>
<th>F</th>
<th>Sig.</th>
<th>df₁</th>
<th>df₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of education</td>
<td>.150</td>
<td>.861</td>
<td>2</td>
<td>262</td>
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<tr>
<td>Teaching experience</td>
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<td>.641</td>
<td>4</td>
<td>258</td>
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<tr>
<td>Length of training</td>
<td>.783</td>
<td>.564</td>
<td>5</td>
<td>122</td>
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*Note.* Dependent variable = Level of implementation.  
\( df₁ = \) equal variance assumed; \( df₂ = \) unequal variance assumed
Perceptions of Innovations as Predictors of TALULAR Implementation

Appendix K

This appendix contains summative tables on t tests on PCIs by gender, school type and training.

Table K1

*Summary results of t tests on PCIs by gender, school type, and training attendance*

<table>
<thead>
<tr>
<th>Grouping Variable</th>
<th>Perception</th>
<th>Mean difference</th>
<th>t</th>
<th>df</th>
<th>p</th>
<th>d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>RAD</td>
<td>-.091</td>
<td>-1.044</td>
<td>267</td>
<td>.297</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>CPE</td>
<td>-.094</td>
<td>-0.948</td>
<td>267</td>
<td>.344</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>CWV</td>
<td>-.145</td>
<td>-1.392</td>
<td>267</td>
<td>.165</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>EOU</td>
<td>-.103</td>
<td>-1.074</td>
<td>267</td>
<td>.284</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>OOU</td>
<td>-.136</td>
<td>-1.325</td>
<td>267</td>
<td>.186</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>OCM</td>
<td>-.123</td>
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<td>267</td>
<td>.183</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>OMS</td>
<td>-.055</td>
<td>-.684</td>
<td>267</td>
<td>.494</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>TRI</td>
<td>-.059</td>
<td>-.570</td>
<td>267</td>
<td>.569</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>VOL</td>
<td>.131</td>
<td>1.311</td>
<td>267</td>
<td>.191</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>IMA</td>
<td>-.143</td>
<td>-1.047</td>
<td>267</td>
<td>.296</td>
<td>-</td>
</tr>
<tr>
<td>School type</td>
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<td>.004</td>
<td>.4b</td>
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<tr>
<td></td>
<td>CPE</td>
<td>.210</td>
<td>2.776**</td>
<td>267</td>
<td>.006</td>
<td>.4b</td>
</tr>
<tr>
<td></td>
<td>CWV</td>
<td>.161</td>
<td>2.011*</td>
<td>267</td>
<td>.045</td>
<td>.3b</td>
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<tr>
<td></td>
<td>EOU</td>
<td>.148</td>
<td>2.016*</td>
<td>267</td>
<td>.045</td>
<td>.3b</td>
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*Note. Mean difference: Gender (M-F), School type (CDSS-CSS), Training attendance (Attended-Not attended).**

**p < .01 (2-tailed), *p < .05 (2-tailed); a Equal variance not assumed. b Small effect size; c Medium effect size.*
### Table K1 (continued)

<table>
<thead>
<tr>
<th>Grouping Variable</th>
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<th>Mean difference</th>
<th>$t$</th>
<th>$df$</th>
<th>$p$</th>
<th>$d$</th>
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</thead>
<tbody>
<tr>
<td>OOU</td>
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<td>.001</td>
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**Training Attendance**

<table>
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<th>$p$</th>
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<td>261</td>
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<td>258.157</td>
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<tr>
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<td>253.098</td>
<td>.001</td>
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<tr>
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<td>261</td>
<td>.000</td>
<td>.6$^c$</td>
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</table>

**Note.** Mean difference: Gender (M-F), School type (CDSS-CSS), Training attendance (Attended-Not attended).

**$^{**}p<.01$ (2-tailed), $^*p<.05$ (2-tailed); $^a$ Equal variance not assumed. $^b$ Small effect size; $^c$ Medium effect size.
This appendix contains summative tables for ANOVA results on PCIs by level of education, experience and length of training, and their post hoc tests.

**Table L1**

*Summary ANOVA results for PCIs by level of education, experience & length of training*

<table>
<thead>
<tr>
<th>PCI</th>
<th>Source</th>
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<th>MS</th>
<th>df</th>
<th>F</th>
<th>p</th>
<th>Effect size ($\eta^2$)</th>
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</thead>
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<td></td>
<td></td>
<td>df</td>
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<tr>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RAD</td>
<td>Level of education</td>
<td>4.778</td>
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<td>2, 266</td>
<td>9.164**</td>
<td>.000</td>
<td>.064^c</td>
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<tr>
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<td>.986</td>
<td>4,262</td>
<td>3.696**</td>
<td>.006</td>
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<td>Length of training</td>
<td>.539</td>
<td>.108</td>
<td>5, 124</td>
<td>.632</td>
<td>.672</td>
<td>-</td>
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<tr>
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<td>Level of education</td>
<td>3.615</td>
<td>1.807</td>
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<td>5.126**</td>
<td>.007</td>
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<td>1.174</td>
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<td>4,262</td>
<td>.779</td>
<td>.526</td>
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<td>1.723</td>
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<td>.444</td>
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</table>

*Note.*  **$p < .01$, *$p < .05$.  $^a$Variances not equal. $^b$Small effect size; $^c$Medium effect size, $^d$Large effect size
### Table L1 (continued)

<table>
<thead>
<tr>
<th>PCI</th>
<th>Source</th>
<th>SS</th>
<th>MS</th>
<th>df</th>
<th>F</th>
<th>p</th>
<th>Effect size ($\eta^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>OOU</td>
<td>Level of education</td>
<td>5.247</td>
<td>2.624</td>
<td>2,266</td>
<td>7.069**</td>
<td>.001</td>
<td>.050&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
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<td>Teaching experience</td>
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<td>.877</td>
<td>4,262</td>
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<td>.060</td>
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<td>.265</td>
<td>5,124</td>
<td>.627</td>
<td>.680</td>
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<td>.002</td>
<td>.046&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>5,124</td>
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<td>1.044</td>
<td>2,266</td>
<td>4.480</td>
<td>.012&lt;sup&gt;*&lt;/sup&gt;</td>
<td>.033&lt;sup&gt;b&lt;/sup&gt;</td>
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<td>4,262</td>
<td>.600</td>
<td>.663</td>
<td>-</td>
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<tr>
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<td>Length of training</td>
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<td>5,124</td>
<td>.937</td>
<td>.459</td>
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<td>2,266</td>
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<td>.019</td>
<td>.029&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
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<td>Teaching experience</td>
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<td>.731</td>
<td>4,262</td>
<td>1.904</td>
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<tr>
<td></td>
<td>Length of training</td>
<td>1.353</td>
<td>.271</td>
<td>5,124</td>
<td>.891</td>
<td>.489</td>
<td>-</td>
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</tbody>
</table>

*Note.* **$p < .01$, *$p < .05$.  <sup>a</sup>Variances not equal.  <sup>b</sup>Small effect size;  <sup>c</sup>Medium effect size,  <sup>d</sup>Large effect size
Perceptions of Innovations as Predictors of TALULAR Implementation

Table L1 (continued)

<table>
<thead>
<tr>
<th>PCI</th>
<th>Source</th>
<th>SS</th>
<th>MS</th>
<th>df</th>
<th>F</th>
<th>p</th>
<th>Effect size ($\eta^2$)</th>
</tr>
</thead>
<tbody>
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<td>.000</td>
<td>.143&lt;sup&gt;d&lt;/sup&gt;</td>
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<td>4, 262</td>
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<td>.000</td>
<td>.094&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>5, 124</td>
<td>.974</td>
<td>.437</td>
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<td>IMA</td>
<td>Level of education</td>
<td>19.245</td>
<td>9.623</td>
<td>2, 266</td>
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<td>.000</td>
<td>.104&lt;sup&gt;c&lt;/sup&gt;</td>
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<td>4, 262</td>
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<td>.047</td>
<td>.036&lt;sup&gt;b&lt;/sup&gt;</td>
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<tr>
<td></td>
<td>Length of training</td>
<td>2.827</td>
<td>.565</td>
<td>5, 124</td>
<td>1.008</td>
<td>.416</td>
<td>-</td>
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</tbody>
</table>

Note. **$p < .01$, *$p < .05$.  <sup>a</sup>Variances not equal. <sup>b</sup>Small effect size; <sup>c</sup>Medium effect size, <sup>d</sup>Large effect size
### Table L2

**Multiple comparisons (post hoc test) results for employment/demographics variables**

<table>
<thead>
<tr>
<th>PCI</th>
<th>Level of education</th>
<th>Mean difference</th>
<th>SE</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAD</td>
<td>Bachelor’s</td>
<td>-.3120(***)</td>
<td>.07837</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Diploma</td>
<td>-.2632(***)</td>
<td>.07624</td>
<td>.002</td>
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<td><strong>Teaching experience</strong></td>
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<tr>
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<td>0-3yrs</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>4-10 yrs</td>
<td>-.3363(*)</td>
<td>.10669</td>
<td>.015</td>
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<tr>
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<td>11-14 yrs</td>
<td>-.2215</td>
<td>.09897</td>
<td>.169</td>
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<tr>
<td></td>
<td>15-20 yrs</td>
<td>-.3233(***)</td>
<td>.09463</td>
<td>.007</td>
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<td>.09097</td>
<td>.019</td>
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*Note.* **The mean difference is significant at the .01 level; *The mean difference is significant at the .05 level.
Table L2 (Continued)

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<td>.000</td>
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<td>.000</td>
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**Teaching experience**

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<th>0-3 yrs</th>
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<th>11-14 yrs</th>
<th>15-20 yrs</th>
<th>&gt;20 yrs</th>
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<td>.4674(**)</td>
<td>.12046</td>
<td>.4320(**)</td>
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<td>.4888(**)</td>
<td>.11618</td>
<td>.4888(**)</td>
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Note. ** The mean difference is significant at the .01 level; *The mean difference is significant at the .05 level.
Table L2 (Continued)

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<td>Diploma</td>
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<tr>
<td></td>
<td>15-20 yrs 0-3 yrs</td>
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<td>.15097</td>
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<tr>
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<td>.16170</td>
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<td>11-14 yrs</td>
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<td>.14868</td>
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<td>&gt;20 yrs</td>
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<td>.15532</td>
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*Note.* **The mean difference is significant at the .01 level; *The mean difference is significant at the .05 level.
Perceptions of Innovations as Predictors of TALULAR Implementation

Appendix M

This appendix consists of summative ANOVA results and post hoc tests for each perception of using TALULAR in relation to the frequency of use (level of implementation).

Table M1

**ANOVA results on perceptions of TALULAR (PCIs) in relation to frequency of use**

<table>
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<tr>
<th>Dependent Variable (PCI)</th>
<th>Factor</th>
<th>SS</th>
<th>MS</th>
<th>df</th>
<th>F</th>
<th>p</th>
<th>Effect size ($\eta^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAD</td>
<td>Frequency of use</td>
<td>9.182</td>
<td>2.295</td>
<td>4, 260</td>
<td>9.269**</td>
<td>.000</td>
<td>.125 c</td>
</tr>
<tr>
<td>CPE</td>
<td>Frequency of use</td>
<td>6.048</td>
<td>1.512</td>
<td>4, 260</td>
<td>4.393**</td>
<td>.002</td>
<td>.063 c</td>
</tr>
<tr>
<td>CWV</td>
<td>Frequency of use</td>
<td>2.267</td>
<td>.567</td>
<td>4, 260</td>
<td>1.411</td>
<td>.231</td>
<td>-</td>
</tr>
<tr>
<td>EOU</td>
<td>Frequency of use</td>
<td>5.091</td>
<td>1.273</td>
<td>4, 260</td>
<td>3.889**</td>
<td>.004</td>
<td>.056 b</td>
</tr>
<tr>
<td>OOU</td>
<td>Frequency of use</td>
<td>6.280</td>
<td>1.570</td>
<td>4, 260</td>
<td>4.235**</td>
<td>.002</td>
<td>.061 c</td>
</tr>
<tr>
<td>OCM</td>
<td>Frequency of use</td>
<td>8.337</td>
<td>2.084</td>
<td>4, 260</td>
<td>7.363**</td>
<td>.000</td>
<td>.102 c</td>
</tr>
<tr>
<td>OMS</td>
<td>Frequency of use</td>
<td>4.383</td>
<td>1.096</td>
<td>4, 260</td>
<td>4.819**</td>
<td>.001</td>
<td>.069 c</td>
</tr>
<tr>
<td>TRI</td>
<td>Frequency of use</td>
<td>6.513</td>
<td>1.628</td>
<td>4, 260</td>
<td>4.522</td>
<td>.002</td>
<td>.065 c</td>
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<td>4, 260</td>
<td>11.021</td>
<td>.000</td>
<td>.145 d</td>
</tr>
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<td>IMA</td>
<td>Frequency of use</td>
<td>20.405</td>
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<td>4, 260</td>
<td>8.209</td>
<td>.000</td>
<td>.112 c</td>
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</table>

*Note.* **p < .01.  
  a Variances not equal,  
b Small effect size;  
c Medium effect size,  
d Large effect size
Perceptions of Innovations as Predictors of TALULAR Implementation

Table M2

Summary post hoc test results on perceptions of TALULAR in relation to frequency of use

<table>
<thead>
<tr>
<th>PCI</th>
<th>Multiple comparisons</th>
<th>Mean difference</th>
<th>SE</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAD</td>
<td>Don't use at all</td>
<td>1-5 times a week</td>
<td>-.4982(*)</td>
<td>.17095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-10 times a week</td>
<td>- .8218(**)</td>
<td>.17850</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-15 times a week</td>
<td>- .7107(**)</td>
<td>.19068</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;15 times a week</td>
<td>- .8235(**)</td>
<td>.19246</td>
</tr>
<tr>
<td></td>
<td>1-5 times in a week</td>
<td>Don't use at all</td>
<td>.4982(*)</td>
<td>.17095</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6-10 times a week</td>
<td>- .3236(**)</td>
<td>.07780</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11-15 times a week</td>
<td>- .2125</td>
<td>.10272</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;15 times a week</td>
<td>- .3253(*)</td>
<td>.10598</td>
</tr>
<tr>
<td>CPE</td>
<td>Don't use at all</td>
<td>1-5 times a week</td>
<td>-.4501</td>
<td>.20154</td>
</tr>
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<td></td>
<td>6-10 times a week</td>
<td>-.7057(**)</td>
<td>.21044</td>
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<td>11-15 times a week</td>
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<td>.22481</td>
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<td>&gt;15 times a week</td>
<td>-.7044(*)</td>
<td>.22690</td>
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<tr>
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<td>1-5 times a week</td>
<td>6-10 times a week</td>
<td>-.2555(*)</td>
<td>.09172</td>
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<tr>
<td>EOU</td>
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<td>Don't use at all</td>
<td>.5961(γ)</td>
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<td></td>
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<td>&gt;15 times a week</td>
<td>.1416</td>
<td>.13538</td>
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</table>

Note. ** The mean difference is significant at the .01 level; *The mean difference is significant at the .05 level.

1 Mean difference not significant at .01 level (i.e., significance was evaluated at .01 because variances are not equal).
Perceptions of Innovations as Predictors of TALULAR Implementation

Table M2 (Continued)

<table>
<thead>
<tr>
<th>PCI</th>
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<th>p</th>
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<tbody>
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<td>.009</td>
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<td>.001</td>
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Note. ** The mean difference is significant at the .01 level; *The mean difference is significant at the .05 level.
### Table M2 (Continued)

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<th>SE</th>
<th>p</th>
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<tr>
<td></td>
<td>1-5 times a week</td>
<td>-1.2509(**)</td>
<td>.28276</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>11-15 times a week</td>
<td>-1.2155(**)</td>
<td>.30207</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>&gt;15 times a week</td>
<td>-1.2160(**)</td>
<td>.30488</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>1-5 times a week</td>
<td>6-10 times a week</td>
<td>-.4520(**)</td>
<td>.12324</td>
</tr>
</tbody>
</table>

*Note.* ** The mean difference is significant at the .01 level; * The mean difference is significant at the .05 level.
Appendix N

This appendix consists of descriptives for frequency of use (level of implementation) categories and frequency of teachers’ concerns about the innovation.

Table N1

Descriptives for frequency of use categories (N=269)

<table>
<thead>
<tr>
<th>Code</th>
<th>Frequency of use category</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Don’t use at all</td>
<td>9</td>
<td>3.4</td>
</tr>
<tr>
<td>2</td>
<td>1-5 times a week</td>
<td>145</td>
<td>54.7</td>
</tr>
<tr>
<td>3</td>
<td>6-10 times a week</td>
<td>57</td>
<td>21.5</td>
</tr>
<tr>
<td>4</td>
<td>11-15 times a week</td>
<td>28</td>
<td>10.6</td>
</tr>
<tr>
<td>5</td>
<td>&gt;15 times a week</td>
<td>26</td>
<td>9.8</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>265</td>
<td>100</td>
</tr>
</tbody>
</table>

Note. Overall statistics for frequency of use (level of implementation): n = 265, M = 2.69, SD = 1.043.

Level of implementation was operationalized as follows: 1: No implementation (do not use at all), 2: Low level of implementation (1-5 times a week), 3: Moderate implementation (6-10 times a week), 4: High level of implementation (11-15 times a week or greater than 15 times a week).
Table N2

*Frequency of teachers’ concerns about the innovation (n = 189)*

<table>
<thead>
<tr>
<th>Concern</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time limitation</td>
<td>48</td>
<td>25</td>
</tr>
<tr>
<td>Ineffectiveness</td>
<td>41</td>
<td>22</td>
</tr>
<tr>
<td>Need for training</td>
<td>40</td>
<td>21</td>
</tr>
<tr>
<td>Scarcity of some local resources</td>
<td>34</td>
<td>18</td>
</tr>
<tr>
<td>Inapplicability in some cases</td>
<td>19</td>
<td>10</td>
</tr>
<tr>
<td>Inadequate funds</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Difficult to design/create</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Limited reusability</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Lack of incentives</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Lack of teacher commitment</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Lack of government commitment</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Null&amp; void</td>
<td>9</td>
<td>5</td>
</tr>
</tbody>
</table>

*Note.*  $n = 59$ (answered they did not have any concerns), $n = 21$ (missing), $n = 189$ (those who responded).