12-2013

SERVICING THE LEARNING NEEDS OF THE DEAF COMMUNITY: AN ACTION DESIGN RESEARCH APPROACH

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Abstract

Several researchers have lamented the fact that despite years of research, English language and literacy development among deaf students have remained elusive and the search for a breakthrough has persisted. Recently, researchers have employed multimedia enhancement methodologies in deaf education. However, they have all built the software and regulated evaluation to a subsequent phase. This research uses an action design research (ADR) methodology, which reflects the premise that IT artifacts are an ensemble, shaped by the organizational context during development and use. A case study is used to describe the ADR stages in the development of beta version of software for deaf students. This paper makes a contribution by developing prescriptive techniques for constructing IT teaching artifacts for deaf education.

Keywords: Deaf Education, Action Design Research, and Software

I. INTRODUCTION

Deaf students have a disadvantage in the initial years of their education compared to their hearing peers and they lag in literacy development as they move to higher grades (Yoon & Kim, 2011 citing Moores, 1997). This linguistic deficiency influences students learning in other subjects as well and their overall academic achievement is delayed relative to that of their hearing peers. Several researchers have lamented the fact that despite years of research, English language and literacy development among deaf students have remained constant and the search for a breakthrough has persisted (Paul, 2000; Qi & Mitchell, 2007; Berent, Kelly, Schmitz & Kenny 2008).

In a quest to develop more efficacious English teaching strategies, Berent (2005) advocated the employment of input enhancement methodologies. As a consequence of Berent's advocacy, a number of researchers employed multimedia methodologies in their research. Researchers employing multimedia methodologies (Yoon & Kin, 2011; Nikolaraizi, Vekiri & Esterbrooks, 2013; and Jabali, 2009) have found that visual aids and multimedia can support the reading comprehension of deaf students. However, there is little research examining how young, deaf and hard of hearing persons use visual resources when they have access to multimedia resources (Nikolaraizi et al 2013). This type of research, the authors declared, could guide researchers and educators in understanding what type of instruction deaf students need in order to use multimedia resources effectively; it can also be used to guide the design and development of software for the deaf.

This paper therefore, proposes the development and testing of multimedia software using Jamaican Sign Language (JSL) and Standard English (SE)/Standard Jamaican English (SJE) to teach young deaf students to use prepositions. Teachers of deaf students in Jamaica and the Jamaica Association for the Deaf (JAD) have indicated that the core problem that Jamaican deaf students face in understanding English is the use of prepositions. The teachers have used a face-to-face teaching approach in an attempt to solve this problem with little success.

The contribution of this paper is two-fold. This paper will contribute to the literature on how young deaf students use visual enhancement and will pioneer the use of Action Design Research (ADR) to develop this type of software. This will help to create a framework for developing software for teaching deaf students. From an Information Systems perspective, this paper will respond to the dual mission of the discipline: make theoretical contribution and assist in solving current and anticipated problem of practitioners.

From a practical perspective, this paper will help to improve the status of Sign Language. Improving the status of Sign Language has consequences for all areas of life for the deaf, as possibilities for participation, access to information and reduction of poverty are opened up. In addition, deaf persons need to use English language in the core of their daily lives. In Jamaica and other countries, mastering and gaining a good English foundation is essential to receiving higher education.

The paper proceeds as follows: the literature review, which presents the justification for the use of ADR in the development of the software, followed by a case study which illustrates how the ADR methodology was applied to the development of software entitled U-Touch. The paper concludes with findings and discussions.

II. LITERATURE REVIEW

Artifact Development in the Deaf Community

The World Federation of the Deaf (WDF), 2007 specified some general cultural guidelines in the development of any artifact for the Deaf Community. The WDF not only opposed all attempts to unify several sign languages to a single language, they strongly proposed that students should be taught in their native sign language. The following is an excerpt from the WDF website regarding its policy on the Unification of Sign Language.

> ‘‘Furthermore, comparisons of both spoken and signed languages have repeatedly confirmed that their developments are strongly influenced by cultural changes. In fact, the development of any language, signed or spoken, and the culture where the language is practiced always is mutually influenced. No culture can emerge without language and no language can emerge without culture.....For these reasons, any attempt to unify Sign Languages practiced in the countries sharing the same spoken or written language is fruitless.’’

The WDF also strongly recommended that any research and or development of artifacts for the deaf should include the Deaf Community’s involvement and ownership. To substantiate their point, the WDF referenced a contentious attempt at sign development in Kosovo (Hoyer 2008), which was met with resistance, antagonism and rejection from many members of the Deaf Community.

Moloney and Church’s (2012) share a similar view as the WDF. They argued, “finding an arrangement where researchers and practitioners can successfully develop both theory and artifact concurrently and in relative harmony is often crucial to the success of the new product and/ or to the rigor of the research outcomes”. Despite these recommendations, few studies have developed and evaluated software in an organizational setting. A 2011 study by Yoon and Kin examined the effects of captions on deaf students’ content comprehension, cognitive load and motivation in online learning. Wang and Paul (2011) evaluated the effectiveness of a literature-based, technology-infused literacy project on deaf students. A more recent study by Nikolaraizi et al (2013), a mixed research design, was used to examine how deaf students used the visual resources of a multimedia software package that was designed to support reading comprehension. All of these researchers took a technological view of the IT artifact paying scant attention to its shaping by the organizational context. The next section will propose an approach to satisfy this requirement.

Action Design Research (ADR)

Sein, Henfridsson, Purao, Rossi & Lindgren (2011) suggested a design research method that simultaneously aimed at building innovative information technology artifacts in an organizational context and learning from the intervention, while addressing a problematic situation. The authors proposed a new research method for design research that drew on Action Research (AR), and labeled it Action Design Research (ADR).

ADR is a research method for generating prescriptive design knowledge through building and evaluating ensemble IT artifacts in an organizational setting (Sein et al 2011). The authors argue that ADR deals with two seemingly disparate challenges: (1) addressing a problem situation encountered in a specific organizational setting by intervening and evaluating: and (2) constructing and evaluating an IT artifact that addresses the class of problems typified by the encountered situation.

The four stages and the corresponding principles of the ADR process described by Sein *et al* (2011) are outlined below and will be applied in the ensuing section.

1. **Problem Formulation:** This provides the impetus for formulating the research effort and has two principles:
    a. *Principle 1- Practice Inspired Research:* This principle emphasizes viewing field problems as opposed to theoretical puzzles as knowledge creation opportunities.
    b. *Principle 2 - Theory-Ingrained Artifact*: This principle emphasizes that the ensemble artifact created and evaluated via ADR are informed by theories.
2. **Building Intervention and Evaluation (BIE):** This stage provides a platform for generating the initial design of the IT artifact and consist of three principles:
    a. *Principle 3 - Reciprocal Sharing:* This principle emphasizes the influences mutually exerted by the two domains; the IT artifact and the organizational context.
    b. *Principle 4 - Mutually Influential Roles:* This principle points to the importance of mutual learning among the participants of different projects..
    c. *Principle 5 - Authentic and Concurrent Evaluation:* This principle emphasizes that evaluation is *not* a separate stage of the research process that follows building.
3. **Reflection and Learning:** This stage moves conceptually from building a solution for a particular instance, to applying that learning to a broader class of problems.
    a. *Principle 6 - Guided Emergence:* Emphasizes that the ensemble artifact will reflect both the preliminary design and also its ongoing shaping by organizational context.
4. **Formulization of Learning:** The objective is to formalize the learning. Following Van Aken (2004), the situated learning from an ADR project should be further developed into general solutions concepts for a class of field problems.
    a. *Principle 7- Generalized Outcomes:* The resulting ensemble is by definition, a bundle of properties in different domains and represents a solution that addresses a problem. Both can be generalized.

III. CASE STUDY

In this section, we illustrate how the ADR lens was used in the development of the multimedia software, provisionally named U-Touch. This study was conducted at the Lister Mair Gilby School for the Deaf (LMG) in Kingston, Jamaica. We will therefore start this section with an overview of the deaf population in Jamaica and a brief description of LMG.

Jamaica's Deaf Population and LMG

The Statistical Institute of Jamaica (2001) reported a total of 2,985 deaf male and 4,085 deaf female. The Jamaican Deaf community uses Jamaican Sign Language (JSL) as their first language, which is different from, but is heavily influenced by, American Sign Language (ASL). The alphabet used is from the ASL.

LMG was named in honor of two pioneers of deaf education in Jamaica, Gladstone Mair and Frederick Gilby. LMG was opened in 1966 and is located in Papine, Kingston. It is the only secondary school for the deaf and currently has a population of approximately 80 students. The school accepts students with varying levels of hearing loss and students must be familiar with JSL to be admitted.

The Development of U-Touch

The following is the detailed description of the development of U-Touch.

Stage 1: Problem Formulation

Principle 1: Practice Inspired Research. The idea for the project was triggered by a colleague who invited a group of Academics from a University in Jamaica to sponsor students from the neighboring LMG for an annual event at their school. The Academics provided the sponsorship requested and subsequently engaged in discussions with the academic staff of LMG about issues that deaf students face. The discussions revealed that only a small number of students was registered to sit the Caribbean Examination Council (CXC) English Language examination. CXC is a Caribbean regional examination and English Language is a required course for matriculation purposes into colleges and universities, and also for gaining employment. To date, the school has had no passes in this subject.

The team from the University proposed the development of software to LMG to help solve the main problem that deaf students have in English comprehension, that is, the use of *prepositions*. The development team from the University did a literature search in the deaf education domain and a concurrent search in the Information Systems (IS) domain to determine if any such artifact exists that deals with the specific problem.

The introduction to this paper outlined some of the issues faced by the deaf population. Some issues that are worth repeating: (i) generally deaf and hard of hearing persons are marginalized and disadvantaged in Jamaica and several other countries and (ii) their economic prospects are blighted by their inability to properly grasp the English Language or their national language. The WDF opposes the use of a unified sign language and also strongly recommends that any research and or development of artifact for the deaf should include the Deaf Community's involvement and ownership.

To avoid these pitfalls mentioned by the WDF, it was necessary to engage the Deaf Community. The researchers had several meetings with the Jamaica Association for the Deaf (JAD) and in particular LMG, to get the school's commitment to the project. We discovered in our early meetings that the Deaf Community is unsurprisingly close knit, suspicious of the intentions to offer help from the hearing community and are insulted by being referred to as 'hearing impaired'.

The researchers received long term commitment to the project from LMG and they wanted the team to focus on prepositions. The problem was framed within the wider ambit of deaf education as a class of problem.

This Client was not able to provide funds for this project and so other sources had to be explored. The University's Research Fund provided some funds and the researchers' recruited students on a service learning basis to augment the shortfall.

Principle 2: Theory-Ingrained Artifact. Sein et al (2011) indicated that the ensemble artifacts created and evaluated via ADR are informed by theories. Sein et al believed that Gregor (2006) theories of Type IV, Explanation and Prediction theories or Type V, Design theories were likely candidates for ADR. Gregor (2006) examined the distinguishing attributes of Type IV and Type V theories. Type IV says what is, how, why, when, where and what will be. It also provides predictions and has both testable propositions and causal explanations. Type V Design and Actions gives explicit prescriptions (e.g. methods, techniques, principles of form and function) for constructing an artifact.

The most widely used theory in developing multimedia software from the deaf literature is Cognitive Theory of Multimedia Learning (CTML) (Nikolaraizi et al 2013; Yoon & Kim 2011; Wang and Paul, 2011). CTML centered on the idea that learners attempt to build meaningful connections between words and pictures and they learn more deeply than they could have with words or pictures alone (Mayer, 2009). Mayer (2009) insisted that research on multimedia instructions must be theory grounded and evidence based. Theory grounded means that each principle, method and concept is derived from a theory of multimedia learning. Evidence based means that each principle, method and concept is supported by an empirical base of replicated findings from rigorous and appropriate studies, which yields testable predications (Mayer 2009). Mayer (2009) developed twelve principles grouped in a framework based on three types of cognitive load.

1. Reducing extraneous processing – coherence, signaling, redundancy, spatial contiguity, temporal contiguity
2. Managing essential processing – segmenting, pre-training, modality
3. Fostering generative processing – multimedia, personalization, voice image.

CTML gives explicit prescriptions on how to construct multi-media teaching software and is therefore a Type V theory. A detailed discussion on CTML can be found in Sorden (2012). CTML was used in the development of the software.

Stage 2: Building Intervention, and Evaluation

In Stage 1, it was determined that the focus of the project should be on developing software to teach prepositions. It was explained to us that deaf and hard of hearing students would omit prepositions in their written and sign expression. For example, students would say '*the cow jump moon'* instead of '*the cow jump over the moon*'.

It was determined early in the discussions that an interpreter would be needed for JSL and Sign English (SE). Independent of the practitioners/teachers, the researchers' explored the use of avatars. A virtual classroom was setup with a common meeting time each week for lecturers and students. In discussions with the LMG teachers, the researchers realized that avatars would not be appropriate. We learned from the teachers how expressive and demonstrative JSL is, as it involves facial expression, body language and mannerisms as communication mechanisms. The avatars that the researchers explored did not have these capabilities. In conjunction with the staff from LMG a decision was made to use video instead of avatars. At an early stage, the researchers realized how important a role the practitioners would play in the design of the software and also became cognizant of the need for close involvement and ownership by the practitioners.

The researchers made several visits to LMG to view how the teachers delivered content and students responses. The teachers, for the benefit of the researchers, used oral communication along with both JSL and SE.

At the design phase, the researchers and the LMG practitioners/teachers were integrally involved in a recursive process of design and evaluation while deaf students were involved later in the process. Using Sein *et al* (2011) locus of innovation approach, the design process would be described as IT-dominant as the focus of the innovation was not organization intervention but more on the design of the software, integrating for the first time, JSL into multimedia content for teaching purposes.

Principle 3: Reciprocal Shaping. This principle emphasizes the inseparable influences mutually exerted by the two domains: the IT artifact and the organizational context. Although the researchers visited several classes at LMG in order to understand the teaching process for deaf students, the researcher also needed to understand the conditions under which the students took examinations especially in SE. It was explained that examinations were given in Standard English and an interpreter would be present only for interpretation of content but not for comprehension. The teachers suggested that from a pedagogical perspective, the researchers should follow the age-old pedagogical axiom of going from the known to the unknown starting with JSL to SE. This meant that, whatever concept we were teaching needed to be done first in JSL and repeated in SE. The researchers and practitioners/teachers decided that the software should have an introduction to preposition, where all the prepositions to be covered would be introduced to the students initially.

Based on the students' curriculum, 100 sentences using prepositions were created. Linguistics from the University, using a method known as 'grammaticality' evaluated the sentences to ensure structure and grammatical formation. This test has been found to be a reliable and valid method of measuring (ASL) competency (Boudreault, 1999). Teachers from LMG who were proficient in JSL also evaluated the sentences for structure and grammar.

Finally, it was decided that the software would consist of three modules**:**

- Module 1. L*earning.* This involved providing students' with an introduction to a range of preposition in JSL, SE and text or captioning.
- Module 2. S*entences: S*tudents were taught how to use the prepositions from Module 1 in sentences.
- Module 3. *Testing:* Without any guidance from the software, students were required to identify the correct prepositions in sentences. At the end of answering each question, the students would be given a score, which would be updated as they progressed through the battery of questions.

A collaborative decision was required to determine how to use the interpreter in the video. This involved discussions with the interpreter (a designated teacher from LMG) and the videographer. We incorporated recommendations and findings from work done by Slike, Berman, Kline, Rebilas & Bosch (2008). The recommendations included:

- A clean and simple background (behind the interpreter) which should be used to minimize distractions for students;
- Lighting: there should be enough light to provide a clear view of the interpreter. However, the interpreter should not be positioned near a window because light from there may interfere with the shot, dimming the view of vital hand movements and facial expressions made by the interpreter;
- Interpreter's clothing: long sleeves should be rolled up for easier viewing of hand movements, and simple, solid-colored clothing should be worn to minimize distraction.

Slike et al (2008) recommendations are with consistent Mayer's (2009) CTML cognitive load reduction principle of reducing extraneous processing; the coherence principle which suggest that people learn better when extraneous material is excluded.

During the conception of the software, the researchers decided that the backbone would be object oriented/functional language. In order to write and compile the C# Language, Visual Studio 2012 IDE was employed. This tool was not only used for this purpose, but also for bridging the connection between itself and Microsoft's SQL Server 2012 which explicitly stored the database used in managing the large amounts of information present in the software such as prepositions, questions, answers, photos and videos. Adobe Photoshop was used to develop the User Interface.

Principle 4: Mutually Influential Roles. This principle points to the importance of mutual learning among the different project participants. During the development of this project the mutually influential roles of the participants were clearly defined, and the development team focused on using technology as a conduit to solve an organizational problem. The role of the practitioners, especially the lead practitioner, was to impart knowledge, explain and highlight organizational peculiarities and end-user issues. The researchers explained the software capabilities and limitations and were receptive to the ideas presented by the LMG staff and key staff members were eager to participate. This relationship contributed significantly to smooth development of the artifact.

*Principle 5: Authentic and Concurrent Evaluation***.** This principle emphasizes a key characteristic of ADR- that decisions about designing, shaping and reshaping of the ensemble artifact and intervening in the organizational work practices should be interwoven with ongoing evaluation (Sein et al 2011).

In the development of this software the end-user/students were not involved in the pedagogical design of the software's (the alpha version), but were integrally involved in the beta version. The beta version emerged based on activities outlined in *Principles* 3 and *4* above.

The beta version of the software was evaluated by students to determine if it met the project objective of not only innovative design, but also to determine the extent to which it met the objective as a teaching tool for deaf students. The methodology applied a systemic approach to investigate the performance of the software as a teaching tool. The researchers used a design-of-experiment approach.

This evaluation methodology is supported by Mayer (2009), which states that "one of the most useful approaches in CTML research is quantitative experimental comparisons, with random assignments and experimental control being two important features". The experiment took place at LMG in classrooms and in computer labs.

The experiment was designed using three (3) treatment groups and one control group. Each treatment group was exposed to different levels of the treatment.

- Treatment Group 1 was exposed to the software for three consecutive one-hour periods over three days.
- Treatment Group 2 was exposed for two consecutive one-hour period
- Treatment Group 3 was exposed for one hour.
- The Control Group received no exposure.

Teachers from LMG were present to explain the purpose of each session and to answer questions from the students. Students were encouraged to proceed through the three modules of software in sequential order, modules 1 through 3. The researchers were present for the duration of the sessions.

At the end of the experiment, all students were required to complete a paper-based test that consisted of forty (40) questions to be completed in sixty minutes. All students received an

incentive of J$120 credit for their cellular phone and each participant's name was entered into a raffle to win a Smartphone.

The subject of this experiment was the student and selection was randomized on two levels, grade level and performance capacity. All students were already exposed to varying levels of teaching in prepositions based on their grade levels.

The grade levels ranged from Grade 7 – 13. The performance levels were: L- high performers, M- intermediate performers and G - low performers. The students' names, grades and levels were entered into a spreadsheet and randomized using the software's 'RAND ()' function. The selection reflected the variation in grade levels and performance levels.

The entire student population of 80 was placed in groups: Treatment Groups 1 – 3 each had 20 students while the Control Group had 19 students. The working null hypotheses for this experiment were:

H_{01}: The distribution of test scores is the same across categories of groups

H_{02}: The distribution of test scores is the same across categories of grades

H_{03}: The distribution of test scores is the same across categories of functional levels

In addition to the experiment, focus groups representing students from the various grade levels and the range of performance levels were conducted to gain qualitative information on student's interaction with the software.

Stage 3: Reflection and Learning

This is a continuous stage and paralleled the first two stages. This stage recognized that the research process involved more than simply solving a problem. Conscious reflection on the problem framing, the theories chosen, and the emerging ensemble is critical to ensure that contributions to knowledge are identified.

The entire development process involved reflection and learning from the initial concept of attempting to use avatars instead of interpreters, only to learn that the richness of JSL is beyond the current capabilities of avatars. Subsequently, the issues with regard to the clothing to be worn by the interpreter and the lighting in the room for the recording of the video were all part of the reflection and learning process.

In the design of the alpha version of the software there was no Module 1: *Prepositional learning,* however, this was decided upon during discussion, brainstorming and reflection with the researchers and staff from LMG. The closed, marginalized and suspicious nature of the Jamaican Deaf Community, coupled with the WDF denouncement of a standardized language and the spectra of the failed attempt in Kosovo to engage in Sign language research without the involvement of the deaf population, were integral in our reflection and learning. The understanding of how interpreters are used to assist deaf and hard of hearing students in examination was also a revelation. In addition, members of the research team have started to communicate with deaf students using JSL.

Also integral in our learning and reflection was the necessity to view this community from a cultural perspective rather than from a hearing disability perspective. The researchers also recognized JSL as a sophisticated language worthy of study and appropriate for daily communication and instructions. In the translation between JSE and JSL, the languages were treated as equal but different.

Principle 6: Guided Emergence. This principle emphasizes that the ensemble artifact will reflect not only the preliminary design (see *Principle 2*) created by the researchers, but also its ongoing shaping by organizational use, perspectives and participants. This software has been tested recently by the wider organization, that is, all LMG language teachers and the Jamaica Association for the Deaf (JAD), so their influence has not been fully incorporated into the artifact and therefore do not reflect organizational use. However, the software has been shaped by on-

going interactions with the LMG staff and small groups of students. Guided emergence was extremely necessary in developing the software in an environment in which the researchers had limited familiarity and communication with the wider population had to be done through an interpreter.

Stage 4: Formalization of Learning

The objective of the fourth stage of ADR is to formalize the learning. The outcomes from the quantitative design of experiment, which will be discussed under findings, the student focus groups and a broader discussion with the Deaf Community have not yet been incorporated in a revised beta version of the software and therefore have not been developed into general solution concepts.

Principle 7: Generalized Outcomes. The class of field problems depicted in this paper can be classified as the development of multimedia teaching software in deaf education. From a design perspective, generalizations can be made based on several theories that were incorporated in this project. We incorporated Cummins (1984), theory of second language learning, which articulates how learners draw on one language to acquire another. A complementary pedagogy was used, moving from the 'known to the unknown', which required that the design be started with JSL. Another theory that was incorporated in the development of U-Touch was (CTML), (Mayer, 2009). As discussed earlier CTML centers on the idea that learners attempt to build meaningful connections between words and pictures and they learn more deeply than they could have with words or pictures alone.

The evaluation of the effectiveness of the beta version of U-Touch was done using an experiment. The outcome and assessment of this research has been formally shared with LMG and the submission of the paper for publication in Pre-ICIS 2013 is an attempt to share the outcomes with other practitioners and a formalization of the results for dissemination.

IV. FINDINGS

The results of the hypothesis testing, outlined in Stage 2, are presented here.

Of the 79 eligible students, only 61 participated. The results were analyzed (in SPSS version 20) using a nonparametric procedure, Kruskal-Wallis Test, with a significant level set at 5%.

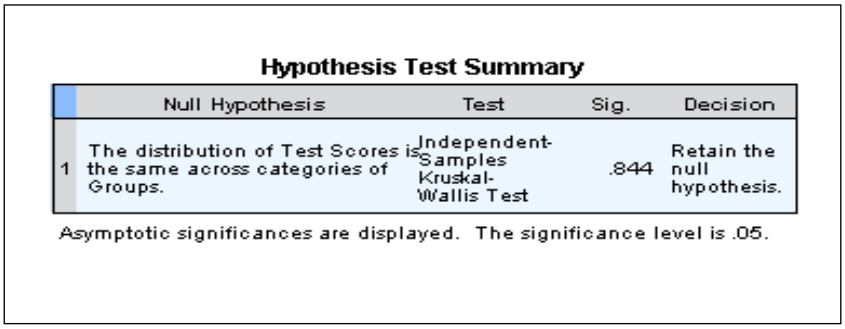
The final groups' composition is shown in Table 1 below.

Table 1. Group Composition

Groups	Frequency	Percent
Treatment 1	16	26
Treatment 2	17	28
Treatment 3	14	23
Control Group	14	23
Total	**61**	**100**

A non-parametric procedure was used to test the hypothesis. The results for the three hypotheses are:

For H_{01} the null hypothesis was retained, meaning that, there was no statistical difference between the groups based on exposure to the software as shown in Figure 1.



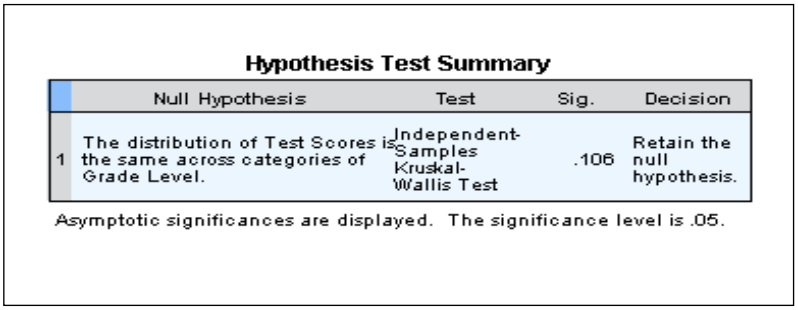
Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Test Scores is the same across categories of Groups.	Independent-Samples Kruskal-Wallis Test	.844	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 1: Group Categories

For H_{02} the null hypothesis was retained, meaning that there was no statistical difference in test scores across grade levels. See Figure 2.



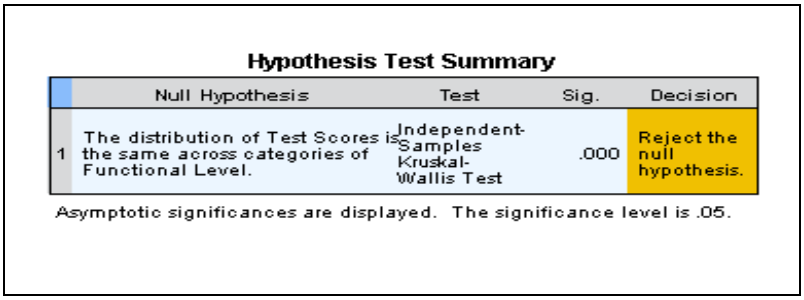
Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Test Scores is the same across categories of Grade Level.	Independent-Samples Kruskal-Wallis Test	.106	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 2: Grade Categories

For H_{03} the null hypothesis was rejected indicating that there was a significant difference in scores based on functional levels. See Figure 3.



Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Test Scores is the same across categories of Functional Level.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 3: Functional Levels

The initial results of the experiment indicate that there were no differences in test scores based on exposure to the treatment.

V. DISCUSSION

A primary concept that we needed to grasp early in the development of 'U-Touch' was bilingualism. In retrospect, the approach was both bilingual and bicultural. The ultimate goal in a bilingual/bicultural approach to educating deaf students is to maximize the students' potential to participate in both the Deaf Community and society as a whole. During our discussions, two perspectives emerged. The perspectives were divided among two groups in the Deaf Community: deaf person and hearing persons. Deaf people emphasize the need to develop fluency in JSL and an awareness of Deaf cultural values, so that students know their identity within the community. While hearing persons emphasized the need for competence in reading and writing English in order to be successful in the world.

The Jamaica Association for the Deaf (JAD) also argued that "given the bilingual context of U-Touch, it would be of value to explain how this grammatical structure presents in the two languages". The JAD's argument is consistent with Cummins (1984), Theory of Second Language Learning. The argument by both Cummins and the JAD suggests that there is a common conceptual core and a common underlying proficiency. A common proficiency facilitates the transfer of cognitive/academic or literacy skills across languages. Evans (2004) argued that this common proficiency does not exist at the surface level in (pronunciation, grammar, vocabulary) in Sign language. Evans (2004) suggests that bilingual programs with deaf students differ from other bilingual programs in three significant ways: (a) language modality (signed vs. spoken/written); (b) the absence of a written form of the first language, JSL; and (c) the inconsistent exposure of deaf children to their first language.

As developers of U-Touch a common ground in this dichotomy of views will be needed to proceed to the next iteration of the software. Evans (2004) indicates that both views are valid and important, and gradually through implementation of bilingual teaching strategies, common ground will be found.

Student Feedback

The comments and/or feedback from the students were generally very positive. The interactivity principle stipulated in CTML literature was highlighted in students' comments. The literature suggest that infusing interactivity such as learner control, feedback and guidance into a multimedia lesson, will increase the effective conditions that will improve learning transfer and performance (Mayer 2009; Renkl & Atkinson 2007). One student commented "*I particularly liked the fact that we could review the clips to better understand how prepositions are used and that there was more signing involved in the use of the software*".

From a learning performance perspective one student indicated that the software helped beyond the teaching of prepositions; "I didn't understand some of the big words, but it did help with my spelling." Another student commented, "*Before, I didn't know the sign for some of the prepositions and now I have learned them*". Another commented, "*I knew the prepositions but didn't know how to use them; but now I know*". The comments are also consistent with the fact that deaf students constitute a heterogeneous group with diverse language needs.

There was a unanimous view that the students preferred using the software to learn prepositions than the traditional method. They particularly liked the fact that they could review the clips to better understand how a preposition is used and that there was more Signing involved in the use of the software. The comments suggest that multimedia software creates a flexible learning environment that can offer students the opportunity to explore information at their own pace and can therefore engage with learning materials in a way that suits their needs, Boone and Higgins (2007).

One person suggested that the software should have levels of difficulty and that they would appreciate having more sentences in the database. This suggestion is consistent with Cannon,

Easterbrooks, Gagne & Beal-Alverez (2011) who commented that "multimedia tools that move children through a program on the basis of each individual child's performance can scaffold students' learning since these tools allow students to make progress depending on their mastery level".

While students thought that the interpreter was effective, they all recommended that a particular teacher who is deaf would have been more effective because he, they say, is more expressive. The teacher that was used as an interpreter is not deaf. Based on student feedback, it appears that these students preferred to have an interpreter who is also deaf in order to communicate more effectively. Further research is required to substantiate this assertion.

Experiment

The initial results of the experiment indicate that there were no differences in test scores based on exposure to the treatment. We expected that this would have been different. However, given the slow rate of English language development exhibited on average by deaf learners (Berent 2008 & Nikolaraizi et al 2013), the findings are not surprising. The software, however, shows promise, as there were significant differences in test scores based on functional levels.

ADR Methodology

Of major concern and a challenge to Educators of deaf students, is *how* to enhance their reading and comprehension skills. This project aimed to design software to assist deaf students to understand prepositions and was ideal for ADR. The ADR lens provided a new approach to the development of multimedia software for Deaf education. ADR deals with two seemingly disparate challenges: (1) addressing the problem situation encountered in a specific organizational setting by intervening and evaluating; and (2) constructing and evaluating an IT artifact that addresses the class of problems typified by the encountered situation (Sein et al 2011). ADR is suitable for use when the Practitioner seeks to identify guidelines for future development of this specific class of systems, especially based on the strong recommendations of WDF to include the Deaf Community in any research and or development of artifact. However, ADR is a new method and relatively untested and this study is intended to contribute to the debate on the approach (Moloney and Church, 2012). The project is, however, not complete and the issues gleaned from the qualitative and quantitative aspect of this project will require that we return to 'stage 2' when the project continues.

VI. CONCLUSION

This paper contributes to the growing literature on engaged scholarship and in particular ADR. The research employed the ADR methodology to design software to assist deaf students to learn prepositions. The ADR methodology was ideal for this on-going project, as it required that the researchers were embedded in the organization in order to the get an appreciation of the issues to be resolved. Stage 2, which involved Principle 1*: Reciprocal shaping;* Principle 2*: Mutually influential roles and* Principle 3*: Authentic and concurrent evaluation* was extremely effective. Despite its elusiveness, with the right software tools, deaf children can learn new vocabulary, numeracy and literacy skills, phonics and social skills in a structured way.

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