Volume 11, No. 1
February 2013
ISSN: 1545-679X

Information Systems Education Journal

In this issue:

The **Information Systems Education Journal** (ISEDJ) is a double-blind peer-reviewed academic journal published by **EDSIG**, the Education Special Interest Group of AITP, the Association of Information Technology Professionals (Chicago, Illinois). Publishing frequency is six times per year. The first year of publication is 2003.

ISEDJ is published online (http://isedjorg) in connection with ISECON, the Information Systems Education Conference, which is also double-blind peer reviewed. Our sister publication, the Proceedings of ISECON (http://isecon.org) features all papers, panels, workshops, and presentations from the conference.

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Relational Algebra and SQL: Better Together

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Abstract

In this paper, we describe how database instructors can teach Relational Algebra and Structured Query Language together through programming. Students write query programs consisting of sequences of Relational Algebra operations vs. Structured Query Language SELECT statements. The query programs can then be run interactively, allowing students to compare the results of Relational Algebra and equivalent Structured Query Language commands. In this way, students better understand both Relational Algebra and Structured Query Language—by writing code and watching it run.

Keywords: database, query, relational algebra, structured query language, SQL.

1. INTRODUCTION

Perhaps the most important topic in a first database course is Codd's relational model for data (Codd, 1970). Relational databases implement logical data structures called tables, and provide ways to perform data-entry and data-retrieval operations on the tables. Substantial class time is spent on how to create, maintain, and query a database.

Classroom discussion of query languages generally leads to a detailed examination of Structured Query Language (SQL). Relational Algebra (RA) as a query language usually receives less attention. This emphasis on SQL distorts database history.

When Codd introduced his relational model in 1970, the main focus was on data independence, with no mention of Relational Algebra or SQL. Two years later, Codd (1972) presented a detailed analysis of RA, along with Relational Calculus. IBM developed two prototype databases based on RA in England in the 1970s (Notley, 1972; Todd, 1976). More recent database systems that offer a form of RA as a query language include LEAP (Layton, 2010) and Rel (Voorhis, 2010).

The initial design of SQL (then called SEQUEL) was performed by Chamberlin and Boyce (1974) at IBM in the early 1970s. This led to the development of several IBM relational database systems based on SQL, including a research prototype System R in the mid-1970s (Chamberlin, et. al, 1981) and the production system DB/2 in 1983. In 1979, Relational Software (now Oracle) introduced the first commercial implementation of SQL.

Why Teach Relational Algebra?

There is widespread agreement that SQL is an essential component of an introductory database course, but there is less support for Relational Algebra (Robbert & Ricardo,2003). Never-the-less, there are several advantages to including RA in a database course.

1. Teaching RA helps students understand the relational model. The relational model with RA operations provides a consistent, powerful way to query a database. RA is not a database design tool, but it can support database analysis and design decisions.
2. Knowledge of RA facilitates teaching and learning the query portion of SQL. The basic syntax of the SQL SELECT statement provides an integrated way to combine RA operations to express a query.
3. An understanding of RA can be used to improve query performance. The query-processing component of a database engine translates SQL code into a query plan that includes RA operations. The query optimizer attempts to speed up query execution by reducing the processing time of each operation.

When to Teach Relational Algebra?

Most database textbooks provide more material on SQL than on RA. Table 1 lists six multiple-edition database textbooks that have a Computer Science (CS) or Information Systems (IS) orientation. For each textbook, the table includes the approximate number of pages devoted to RA and to the query features of SQL. The page counts in Table 1 do not include non-query aspects of SQL. All except Date's book have more pages explaining SQL than RA.

Three of the textbooks in Table 1 introduce RA before SQL, while the other three explain SQL first. If an instructor covers RA first, then SQL can be introduced by showing how the RA operations can be performed with SQL. If SQL is presented first, then SQL query statements can be decomposed into a corresponding sequence of RA operations.

Table 1: Database Textbook Summary.

Database Textbook	SQL pages	RA pages	First topic
Connolly & Begg, 5th ed, 2010	34	13	RA
Date, 8th ed, 2004	34	45	SQL
Elmasri & Navathe, 6th ed, 2010	44	29	SQL
Ramakrishnan & Gehrke, 3rd ed, 2002	33	14	RA
Silberschatz, et al, 6th ed, 2010	42	22	SQL
Ullman & Widom, 3rd ed, 2008	48	30	RA

The SQL SELECT statement includes query operations that go beyond RA, such as ordering, grouping, and aggregate functions. If RA has been discussed first, these additional SQL operations can be presented as extensions to RA. If SQL has been covered first, then RA can be described as a subset of the query capabilities provided by SQL. In either case, a student's understanding of the relational model and query languages is improved when RA and SQL reinforce each other.

Other authors have presented innovative ways to teach SQL, such as by using case studies (Caldeira, 2008) or by combining SQL and Java to build web applications (Pereira, Raoufi & and Frost, 2012). Our emphasis in this paper is on teaching Relational Algebra. The advantage of using RA to help students learn SQL is a side benefit of our approach.

2. AN EXAMPLE DATABASE

To illustrate query programming with SQL and Relational Algebra, we define an example database. The logical structure of a Time-and-

Billing system for the fictional X-Files group within the FBI consists of three tables: AGENT, CASES, and TIMECARD. The relational model for this XFILES database is shown in Figure 1. Primary keys are marked in bold.

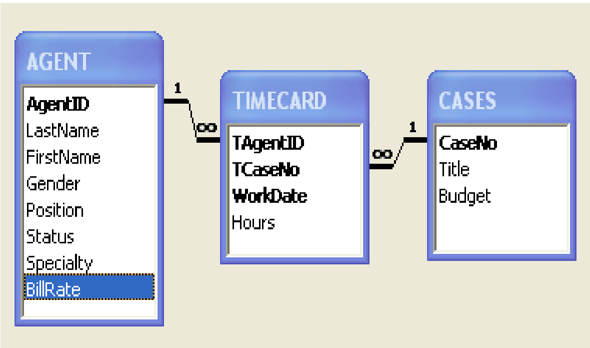

Figure 1: XFILES Database

In this data model, agents are assigned to various cases. Several agents often work together on a case, and each agent can work on multiple cases. The number of hours charged by an agent to a case is recorded each day in the TIMECARD table. Sample data for the XFILES database is given in the Appendix.

Consider the following Query1 for the XFILES database.

Query1: List the agent ID and last name of all female agents that have worked on Case 2803.

An SQL statement to perform Query1 is shown below. This SELECT statement combines several RA operations (*select*, *project*, and *join*) into one command.

```
SELECT DISTINCT AgentID, LastName
FROM AGENT, TIMECARD
WHERE AgentID = TAgentID
  AND Gender = 'F'
  AND TCaseNo = 2803
```

3. RELATIONAL ALGEBRA QUERIES

Teaching SQL in a database course is relatively straightforward. Sections of the SELECT command can be covered in the order favored by the instructor or the textbook. When query execution is desired, many database products are available that implement SQL as the primary query language. This includes commercial systems such as Oracle and SQL Server, as well as free software such as MySQL. SQL queries can also be run in Microsoft Access using the SQL View screen.

If an instructor decides to include Relational Algebra in a database course, how should this topic be presented? RA coverage in leading database textbooks often takes a mathematical approach (Elmasri & Navathe, 2010), (Silberschatz, Korth, & Sudarshan, 2010), (Ullman & Widom, 2008). Most database students are not comfortable with a mathematical notation that uses Greek letters in new contexts, along with other strange symbols. A greater problem with the math syntax is that students cannot execute query programs written in the mathematical notation.

The mathematical approach for RA contrasts with the way SQL is taught. With SQL, an important part of learning occurs when students run their query statements. Errors in program execution provide feedback to help students reconcile their understanding of the problem with the proposed solution. Unfortunately, few computing environments are available for running Relational Algebra programs. One current system that does support a form of RA is LEAP (Leyton, 2010).

In this paper, we present a non-mathematical, function-based Relational Algebra language for writing query programs. We then describe a custom RA and SQL (RASQL) software environment that can execute both RA and SQL query programs on Microsoft Access databases.

RA Query Programs

Table 2: RA Query Functions

Operation	Function
selection	TSelect(Table1,RowCondition)
projection	TProject(Table1,ColumnList)
join	TJoin(Table1,Table2,JoinCondition)
union	TUnion(Table1,Table2)
intersection	TIntersect(Table1,Table2)
difference	TMinus(Table1,Table2)
product	TProduct(Table1,Table2)
division	TDivide(Table1,Table2)
rename	TRename(Table1,OldColumnName, NewColumnName)

In our Relational Algebra syntax, a query program consists of a sequence of statements that specify operations to perform on database tables. Each statement is a function call that performs one RA operation. Functions are defined for the nine RA operations listed in Table 2. We start each function name with the letter "T" to avoid conflicts with SQL keywords.

Each RA function receives one or two tables as input and returns a temporary table. The temporary table can be used in later RA operations. Using function calls for operations provides a familiar programming environment for CS and IS students.

A sample RA program for Query1 using these functions is shown below.

```
-- Query1: XFILES Database
T1 = TJoin('AGENT','TIMECARD',
     "AgentID=TAgentID")
T2 = TSelect(T1,"Gender='F'")
T3 = TSelect(T2,"TCaseNo=2803")
T4 = TProject(T3,"AgentID,LastName")
```

An explanation of each line of code for this program follows:

Line 1: This is a comment (--)

Line 2: The AGENT and TIMECARD tables are *joined* based on the condition that the AgentID (PK) field matches the TAgentID (FK) field. The output table is assigned to variable T1.

Line 3: Rows of table T1 are then *selected* when the Gender field value is 'F' (female). The output table variable is named T2.

Line 4: Rows of table T2 are *selected* when the TCaseNo field equals 2803. The output table is assigned to variable T3.

Line 5: The two attributes of table T3 specified in the column list are *projected* as table T4 (the result table for the query).

RASQL Software

Our RA and SQL (RASQL) query software allows us to execute queries written in the RA format demonstrated by the Query1 program, as well as SQL SELECT statements. An earlier version of the software provided the ability to run RA query programs but not SQL.

Our explanation of how to use RASQL is presented in order of the controls that appear on the Main Screen (Figure 2).

1. *Database File* textbox: Select a database. The database must be in an Access MDB (not ACCDB) file. We chose this database format, because MDB files are easy to distribute to students.

2. *Query Program* textbox: Choose a query program consisting of a sequence of RA and/or SQL statements. Each RA instruction must be on a single line. SQL statements can span multiple lines. Query programs must be in a text file with a TXT extension.

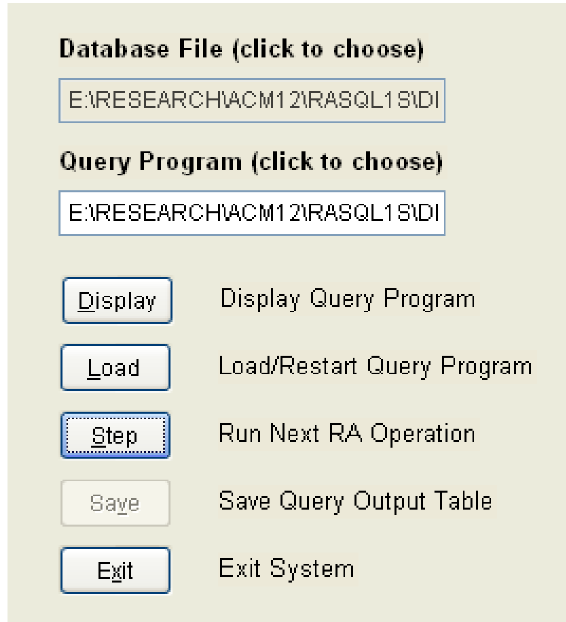

Figure 2: RASQL Program Main Screen

3. *Display* button: Display the query program code in a window (read-only). Use a separate text editor to create and modify the programs.

4. *Load* button: Before a query program can run, it must be loaded (initialized). Repeating this action restarts the program from the beginning.

5. *Step* button: Each click of this button executes one RA or SQL instruction. Comments in the program code are skipped. The output table for each step is shown on the screen.

6. *Save* button: When an RA or SQL instruction has successfully completed, the current output table can be saved to disk as an Excel XLS file.

7. *Exit* button: Click this button to exit the RASQL system.

The final output table from the RA program for Query1, using the data in the sample XFILES database, is presented in Figure 3. The result table for the Query1 SELECT statement (with DISTINCT) is identical. Without the DISTINCT keyword, the SQL output lists duplicate rows.

Agentid	Lastname
FB210	Scully
FB340	Reyes

Figure 3: RASQL Query1 Result Table

When an SQL SELECT statement is included in a RASQL query program, the statement can extend across multiple lines. The special keyword ENDSQL (not case-sensitive) must be placed at the end of the statement to designate where the statement terminates.

4. RA AND SQL TOGETHER

The RASQL software can be used to teach Relational Algebra and SQL concepts together. The advantage of mixing SQL and RA in query programs is that it helps students visualize how RA concepts relate to SQL. Some examples of query concepts that can benefit from this integrated approach are described below.

Select Before Join

Relational algebra is a *procedural* language, in that a sequence of operations must be specified for each query. However, different orderings of RA operations can produce identical solutions. Although the end result may be the same, the code versions can vary greatly in terms of resources and performance.
Consider the following revised RA program for Query1. In this version, the *select* operations are performed before the *join*.

```
-- Query1 revised: Select before Join
T1 = TSelect('AGENT',"Gender='F'")
T2=TSelect('TIMECARD',"TCaseNo=2803")
T3 = TJoin(T1,T2,"AgentID=TAgentID")
T4 = TProject(T3,"AgentID,LastName")
```

In the original Query1 program, the join operation is performed first, so table T1 has as many rows as the TIMECARD table. When the select operations are performed before the join, the join table T3 is much smaller, because it is restricted to female agents from the AGENT table. It is also based only on rows for Case 2803 from the TIMECARD table.

Table T3 is the same in both RA versions. The advantage of performing select operations early and join operations later is obvious as the RA program executes step-by-step in RASQL.

In the SQL SELECT statement for Query1, the intermediate operations are unseen by the user. The DBMS query optimizer makes choices among alternative algorithms. Because the intermediate results of the underlying calculations are not visible, SQL appears to be more *non-procedural*.

Product vs. Join

Joining two tables is equivalent to performing a *product* operation followed by a *select* operation. For example, the first line of the Query1 RA program:

```
T1 = TJoin('AGENT','TIMECARD',
     "AgentID=TAgentID")
```

could be split into two operations as follows:

```
T0 = TProduct('AGENT','TIMECARD')
T1 = TSelect(T0,"AgentID=TAgentID")
```

Table T1 and the final result for Query1 (shown in Figure 3) would be unchanged, but the rewritten version requires an extra (relatively large) temporary table T0.

Union and Union-Compatible

The *union* of tables A and B consists of the combined set of rows of A and B. Because the union is a set, listing duplicate rows is redundant. The union operation in RA follows this convention and eliminates duplicate rows automatically. SQL provides the option to show (UNION ALL) or not show (UNION) duplicate rows. To illustrate the union operation in SQL and RA, consider Query2 stated below.

Query2: List the agent ID and last name of all agents that are male *or* have worked on Case 2801.

An SQL statement for this query, including the ENDSQL keyword required to run in RASQL, is shown below.

```
SELECT AgentID, LastName
FROM AGENT
WHERE Gender = 'M'
UNION
SELECT AgentID, LastName
FROM AGENT, TIMECARD
WHERE AgentID = TAgentID
  AND TCaseNo = 2801
ENDSQL
```

Because this statement contains the UNION keyword (instead of UNION ALL), DISTINCT is not needed, and duplicate rows from the two SELECT sections will not be displayed.

The Query2 result table for this SQL statement, using the XFILES database, is displayed in Figure 4.

Agentid	Lastname
FB160	Skinner
FB180	Mulder
FB210	Scully
FB270	Doggett

Figure 4: RASQL Query2 Result Table

The row "FB270 Doggett", representing the only male agent to work on Case 2801, appears just once.

A comparable RA program for Query2 is listed below. With this query program, duplicate rows in tables T2 and T5 are not repeated in table T6. The result table T6 is identical to the one shown in Figure 4.

```
-- Query2: Union Operation
T1 = TSelect('AGENT',"Gender='M'")
T2 = TProject(T1,"AgentID,LastName")
T3 = TJoin('AGENT','TIMECARD',
     "AgentID=TAgentID")
T4 = TSelect(T3,"TCaseNo=2801")
T5 = TProject(T4,"AgentID,LastName")
T6 = TUnion(T2,T5)
```

The union operation requires the two input tables to be *union-compatible*. That is, they must have the same number of columns, with matching domains for the columns. In this Query2 example, both tables (each SELECT part in the SQL statement, or tables T2 and T5 in the RA program) have the same columns--AgentID and LastName. When two tables are not union-compatible, the union operation is undefined.

Intersection and Difference

Relational algebra includes two additional set operations. The *intersection* of tables A and B is the set of rows that are simultaneously in A and in B. The *difference* A - B includes all rows of A that are not in B. As with union, the intersection and difference operations expect the input tables to be union-compatible. The SQL keyword for the intersection operation is INTERSECT. The difference operation is called MINUS in Oracle and EXCEPT in the SQL standard. In our RA library, the function names are TIntersect and TMinus.

The following Query3 and its SQL and RA programs demonstrate the difference operation.

Query3: List the agent ID and specialty of all agents that have *not* worked on Case 2804.

An SQL statement for this query, including the ENDSQL keyword (RASQL format), is listed next. This SQL statement first collects all rows from AGENT and then removes those for agents who have worked on Case 2804.

```
SELECT AgentID, Specialty
FROM AGENT
MINUS
SELECT AgentID, Specialty
FROM AGENT, TIMECARD
WHERE AgentID = TAgentID
  AND TCaseNo = 2804
ENDSQL
```

A corresponding RA program for Query3 is listed below.

```
-- Query3: Difference Operation
T1 = TProject('AGENT',
     "AgentID,Specialty")
T2 = TJoin('AGENT','TIMECARD',
     "AgentID=TAgentID")
T3 = TSelect(T2,"TCaseNo=2804")
T4 = TProject(T3,"AgentID,Specialty")
T5 = TMinus(T1,T4)
```

In this RA program, table T1 includes all agents, and T4 lists those who worked on Case 2804. The difference table T5 consists of all agents who have not worked on that case.

Sample output for the Query3 SQL statement and RA program, using the XFILES database, is presented in Figure 5.

Agentid	Specialty
FB160	Management
FB180	Parapsychology
FB210	Medicine
FB480	Computers

Figure 5: RASQL Query3 Result Table

The rows that do not appear in Figure 5 represent the agents in the intersection of the two tables (T1 and T4 in the RA program). These rows are:

FB270	Military Tactics
FB340	Folklore and Mythology

We note that in SQL it is common to use *subqueries* (with IN or NOT IN) to implement queries involving intersections and differences. One reason for this is that some database systems do not support the INTERSECT and MINUS/EXCEPT keywords.

5. RASQL LIMITATIONS

The RASQL software was designed to provide a convenient academic environment for teaching Relational Algebra and SQL together through programming. Several limitations and constraints for using the software are described below.

1. RASQL provides modest error checking. Error messages show the offending line of code but not the reason for the error.

2. Duplicate field names should be avoided in databases. If necessary, use the TRename function in RA programs. This is a constraint inherent in Relational Algebra (Date, 2004). SQL can handle duplicate names using aliases.

3. Nesting of RA function calls within a single statement is permitted but not recommended. Nested function calls defeat the opportunity to see intermediate RA tables. SQL statements hide all but the final query result.

4. Date fields can be included in queries. To specify date constants in row conditions, use the *toDate* function (similar to Oracle's *to_date* function), which returns a date datatype. The format for our toDate function is:

    toDate(year, month, day).

5. The RASQL software has been tested in Windows XP, Windows Vista, and Windows 7. Administrative privileges may be required for Vista or Windows 7.

6. CONCLUSIONS

In this paper, we present reasons for integrating Relational Algebra and SQL in database courses. We suggest that, in teaching RA to database students, a programming approach is preferable to a mathematical approach. Our chosen syntax is to write RA query programs as a sequence of function calls, where each function performs one RA operation. Applying this format, students can gain experience using a procedural query language. Query programs can also be written with non-procedural SQL SELECT statements, or as a combination of RA and SQL instructions.

Learning is enhanced when students can both write and execute query programs. According to Knuth (1974), "... a person does not really understand something until after teaching it to a computer." To ensure that the computer has interpreted our intent correctly, we must be able to run our programs and receive feedback. This is a common learning style in most computing courses.

There are readily available database systems for performing SQL queries, but very few for RA. Because of this, we developed a custom Relational Algebra and SQL (RASQL) software environment in which both RA and SQL programs can run.

The RASQL software allows students to see intermediate results during a sequence of RA and SQL instructions. With this capability, students can visualize how RA operations behave, and relate these operations to SQL statements. Using several example queries, we demonstrated how RA and SQL are interrelated conceptually and functionally. This experience can improve students' understanding of database query languages and the relational model.

We have been using various versions of our Relational Algebra software in database courses for several years. Most of our evidence regarding the utility of the software in teaching RA and SQL has been favorable but non-empirical. Students are able to effectively write and run Relational Algebra queries. However, no formal assessment of the benefits of this approach in teaching SQL has been established.

In future research, we hope to confirm the symbiotic relationship between learning Relational Algebra and learning SQL. We intend to measure how well a student's understanding of RA improves his/her ability to write SQL query statements, and vice versa. This followup research has been delayed until the authors are again scheduled to teach database courses during the same semester.

Note: An executable version of the RASQL program, runtime files, and the XFILES database and sample RA and SQL programs described in this paper, can be obtained from the lead author.

7. REFERENCES

Caldeira, C. (2008). Teaching SQL: A Case Study. *ITiCSE '08*: Proceedings of the 13th annual conference on Innovation and Technology in Computer Science Education, June 30 - July 2, Madrid, Spain: 340.

Chamberlin, D., and Boyce, R. (1974). SEQUEL: A structured English query language. Proceedings of the 1974 ACM SIGFIDET (now SIGMOD) workshop on Data description, access and control, pp 249-264.

Chamberlin, D., et. al. (1981). A History and Evaluation of System R. Communications of the ACM, Vol 24, No. 10, pp 632-646.

Codd, E.F. (1970). A relational model of data for large shared data banks. *Comm. ACM* IS, 6.

Codd, E. F. (1972). Relational Completeness of Data Base Sublanguages. In Rustin, Randall (ed.), *Data Base Systems*, Courant Computer Science Series 6. Prentice Hall.

Connolly, T., and Begg, C. (2010). *Database Systems: A Practical Approach to Design, Implementation, and Management* (5th ed). Addison-Wesley.

Date, C. J. (2004). *An Introduction to Database Systems* (8th ed). Addison-Wesley.

Elmasri, R., and Navathe, S. (2010). *Fundamentals of Database Systems* (6th ed). Addison-Wesley.

Knuth, D. (1974). Computer Science and Its Relation to Mathematics. In *The American Mathematical Monthly*, 81, pp 323-343.

Leyton, R. (2010). LEAP RDBMS: An Educational Relational Database Management System. Retrieved from http://leap.sourceforge.net.

Notley, M. (1972). The Peterlee IS/1 System. Rep. UKSC-18, IBM UK Scientific Centre, Peterlee, England.

Pereira, A., Raoufi, M., and Frost, J. (2012). Using MySQL and JDBC in New Teaching Methods for Undergraduate Database Systems Courses. In Lecture Notes in Computer Science, 2012, Volume 6411/2012, pp 245-248.

Ramakrishnan, R., and Gehrke, J. (2002). *Database Management Systems* (3rd ed). McGraw Hill

Robbert, M., and Ricardo, C. (2003). Trends in the Evolution of the Database Curriculum. *Proceedings of the 8th Annual Conference on Innovation and Technology in Computer Science Education*. Greece.

Silberschatz, A., Korth, H., and Sudarshan, S. (2010). *Database System Concepts* (6th ed). McGraw Hill.

Todd, S. (1976). The Peterlee Relational Test Vehicle - A System Overview. *IBM Systems Journal*, 15(4), pp 285-308.

Ullman, J., and Widom, J. (2008). *A First Course in Database Systems* (3rd ed). Prentice Hall.

Voorhis, D. (2010). An Implementation of Date and Darwen's Tutorial D Database Language. dappbuilder.sourceforge.net/Rel.php.

Editor's Note:

This paper was selected for inclusion in the journal as a ISECON 2012 Meritorious Paper. The acceptance rate is typically 15% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2012.

8. APPENDIX: XFILES DATABASE

AGENT table

AgentID	LastName	FirstName	Gender	Position	Status	Specialty	BillRate
FB160	Skinner	Walter	M	Deputy Director	Active	Management	120
FB180	Mulder	Fox	M	Special Agent	Abducted	Parapsychology	90
FB210	Scully	Dana	F	Special Agent	Active	Medicine	96
FB270	Doggett	John	M	Special Agent	Active	Military Tactics	72
FB340	Reyes	Monica	F	Special Agent	Active	Folklore and Mythology	72
FB480	Wildcat	Wendy	F	Student Intern	Temporary	Computers	30

TIMECARD table

TAgentID	TCaseNo	WorkDate	Hours
FB210	2801	10/18/2012	4
FB210	2802	10/18/2012	4
FB270	2801	10/18/2012	4
FB270	2804	10/18/2012	4
FB210	2803	10/19/2012	8
FB270	2803	10/19/2012	8
FB210	2803	10/22/2012	8
FB270	2803	10/22/2012	8
FB340	2802	10/22/2012	4
FB340	2803	10/22/2012	4
FB210	2801	10/23/2012	4
FB210	2802	10/23/2012	4
FB270	2802	10/23/2012	4
FB270	2804	10/23/2012	4
FB340	2802	10/23/2012	4
FB340	2805	10/23/2012	4
FB210	2801	10/24/2012	8
FB270	2805	10/24/2012	8
FB340	2805	10/24/2012	8
FB210	2803	10/25/2012	8
FB270	2801	10/25/2012	2
FB270	2805	10/25/2012	6
FB340	2805	10/25/2012	8
FB210	2801	10/26/2012	2
FB210	2802	10/26/2012	6
FB270	2802	10/26/2012	6
FB270	2804	10/26/2012	2
FB340	2804	10/26/2012	4
FB340	2805	10/26/2012	4

CASES table

CaseNo	Title	Budget
2801	Bermuda Triangle	75000
2802	Dark Matter	40000
2803	Swamp Monster	35000
2804	Alien Cockroaches	25000
2805	Flame-Throwing Aliens	50000
2806	Fat-Sucking Vampire	25000

Comparing Top-down with Bottom-up Approaches: Teaching Data Modeling

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Abstract

Conceptual database design is a difficult task for novice database designers, such as students, and is also therefore particularly challenging for database educators to teach. In the teaching of database design, two general approaches are frequently emphasized: top-down and bottom-up. In this paper, we present an empirical comparison of students' performance between these two approaches in a conceptual data modeling exercise. Our results indicate that, while prior database education had a significant effect on the quality of design performance, the chosen approach did not. The findings suggest that database educators should integrate both top-down and bottom-up approaches in database design showing the differences and similarities between the two approaches to improve students' learning of data modeling.

Keywords: data model, entity relationship diagram, relational model, normalization

1. INTRODUCTION

Teaching database design remains an important topic as *data and information management* remains a core course in the IS 2010 undergraduate IS curriculum (Topi, Valacich, Wright, Kaiser, Nunamaker, Sipior, & De Vreeda, 2009). While there are many database textbooks devoted to presenting various approaches, methods, and techniques for database design, teaching practices vary considerably, and there is an ongoing debate with regards to the effectiveness of certain approaches both within the classroom and in practice (Fotache, 2006). This paper presents empirical results of an investigation into the effectiveness of two common, but contrasting, approaches to database design (namely, top-down and bottom-up approaches) within a classroom setting.

The database design process aims to create database structures that will efficiently store and manage data (Rob & Coronel, 2004). Database design has four phases: requirements analysis, conceptual design, logical design, and physical design. Notwithstanding, it is common within

Information Systems (IS) university courses in data management to present the primary aim of database design as the development of an acceptable logical data model, i.e., relational schema design. The final stage of database design (physical design) is frequently deemphasized, as IS graduates are normally expected to be less knowledgeable in issues such as the design of indexes and denormalization. Within the field of database design, a recurring distinction is made between top-down and bottom-up approaches. This tradition of duality suggests two different paths towards the development of an acceptable logical data model.

Top-Down and Bottom-up Approaches to Database Design

Top-down approaches stress an initial focus on knowledge of higher-level constructs, such as identification of populations and collections of things and entity types, membership rules, and relationships between such populations. Adoption of a top-down approach will generally start with a set of high-level requirements, such as a narrative. These requirements start a process of identifying the types of things needed to represent data with as well as the attributes of those things, which may become attributes in tables.

In the top-down database design tradition, the database analyst initially attempts to develop a conceptual data model by identifying highly abstracted data objects (things/entity types) that may exist within the domain—i.e., the analyst attempts to construct a domain ontology. Techniques applied by the analyst typically include making observations, conducting interviews, and other data collection strategies. Usually, inspiration for the data model also comes from a close analysis of the domain business rules. In addition, structural properties, such as relationships between entity types and relationship cardinality are identified. In many cases, an initial conceptual data model is drafted that does not include all data attributes. Once a satisfactory conceptual data model has been developed, the database analyst may turn his/her attention to the technological platform on which the final data repository will be deployed (i.e., development of the logical data schema). Development of the logical schema requires the database analyst to consider any mapping issues between the structures on the ER (Entity-Relationship) model and chosen persistent mechanism.

Historically, the most common persistent mechanism used by organizations has been either a relational or object-relational database. Commonly, top-down approaches have utilized diagrammatic approaches, such as conceptual data models (e.g., ER diagrams). Notwithstanding, ER diagrams have also been featured in bottom-up approaches. For example, Shoval, Danoch & Balabam (2004) present a bottom-up approach to developing conceptual data models that produce ER diagrams at increasingly higher levels of abstraction; while Teory, Wei, Bolton & Koenig (1989) present a bottom-up approach based on the principle of entity clustering.

In contrast, bottom-up approaches view database design as proceeding from an initial analysis of lower-level conceptual units, such as attributes and functional dependencies and then moving towards an acceptable logical data model through logical groupings of associated attributes. In other words, bottom-up approaches tend to view the task of population identification as a process of generalizing object identity from examples of structural dependencies (e.g., bundling/categorizing attributes that appear to co-occur). Input into a bottom-up approach, for example, could be views of data, such as screen shots or reports (printouts), or patterns of co-occurring attribute values identified within large datasets. A well-known approach to database design that can be used as a bottom-up approach is normalization (Connolly & Begg, 2000). By addressing potential deficiencies in a relational schema design associated with different levels of normal form, relations are defined to minimize redundancy and dependency. It is also common that normalization is infused with top-down approaches, such as using ER diagrams, as a logical check on the adequacy of the final relational schema.

The distinction between top-down and bottom-up approaches to database design is also highlighted in early theoretical work on conceptual data modeling and database design. Bernstein (1976) pioneered an approach to database design based upon the *synthesis* of relations (*synthesis* in this context relates to its philosophical meaning: "logical deduction"). It is of interest to note that Bernstein's paper, which was published in the same year as Chen's

(1976) seminal work on ER modeling, presented a distinct alternate approach to database design to that proposed by Chen. Although both papers focused on producing provably sound logical database schemas and addressing semantic constraints, Chen's approach can be considered an exemplar of top-down design, while Bernstein's approach presents a bottom-up database design methodology. Bernstein's synthesis approach is clearly predicated upon Codd's (1970) seminal work on normal forms and therefore provided a direct contrast to Chen's (1976) work – Chen's work was actually originally presented as an alternate approach to Codd's (1970) approach to database design, but one "with clearer semantics" and an approach not using "the transformation operation" (Chen, 1976, p.28).

Another form of the top-down versus bottom-up process comes from Hoffer, Ramesh & Topi (2010), who advocate two distinct approaches for identifying supertype/subtype structures within ER diagrams: specialization (top-down) and generalization (bottom-up). With generalization, the design process proceeds in a bottom-up manner, in which multiple entity sets are synthesized into a higher-level entity set on the basis of common features. The process of designating subgroupings within an entity set is called specialization. Choice of technique would depend on "several factors such as the nature of the problem domain, previous modeling efforts, and personal preference." (Hoffer et al., 2010).

Some data management textbooks have been criticized for incomplete and confusing treatment of important concepts within database design, such as definitions of a relation and first normal form (e.g., Philip, 2007). In addition, Fotache (2006) found a degree of confusion with respect to the role and importance of normalization within database design: some popular textbooks on database design did not feature normalization at all, or very little. Moreover, with regards to integrating normalization with top-down approaches, such as using ER diagrams, there are also different approaches and opinions (Fotache, 2006). Another concern is that data management textbooks seldom offer concrete advice as to under which circumstances a specific approach should be applied.

Overall, we contend that with many different opinions of the application of top-down and bottom-up approaches, it is not surprising that students may actually become more confused as to the true merits of each approach and their theoretical distinctions. Moreover, as many data management textbooks fail to clearly acknowledge the strengths and limitations of the top-down and bottom-up approaches, students commonly draw false conclusions that both approaches will always produce the same relational schema design, or that both approaches need to be applied before a final, acceptable relational schema can be produced.

2. RESEARCH QUESTIONS

From a teaching perspective, while most database and systems analysis and design textbooks cover both the ER modeling and the relational data model, it remains unclear as to how to best integrate both of these design methods. In addition, little empirical data exists to substantiate the true strengths and weaknesses of each approach. Such concerns are summarized through the following research questions:

- Does a certain teaching approach, emphasizing either top-down or bottom-up, result in better student database design performance?
- Do students experience difficulty in integrating the two design approaches formulating their final database design?

In this study, we address these research questions by comparing the performance of students across different database design methods, in which either a top-down or bottom-up approach was emphasized (e.g., an ER modeling approach vis-à-vis an approach based upon the relational data model).

The following section of this paper describes the research design and data collection procedure. We then present the data analyses and results of the study. The concluding section summarizes contributions and limitations of the study.

3. RESEARCH FRAMEWORK AND HYPOTHESES

The research framework is shown in Figure 1. Designer performance is the dependent variable, and is measured by error rate. The model predicts that designer performance will be affected by the teaching of data modeling approach and designer experience (course).

Our main interest is to identify any performance differences between the different approaches to the teaching of data modeling (top-down versus bottom-up) and course (Systems Analysis and Design (SA&D), Data Management (DM), and Business Systems Analysis (BSA)). As no prior empirical work has compared the two data modeling teaching approaches directly, it is therefore difficult to predict which approach will result in superior performance; however, given that most textbooks and database-related courses have traditionally emphasized a top-down approach to database design over a bottom-up one, it is plausible to support the notion that novice database designers using the ER modeling approach will perform better than those using the relational model (normalization) approach.

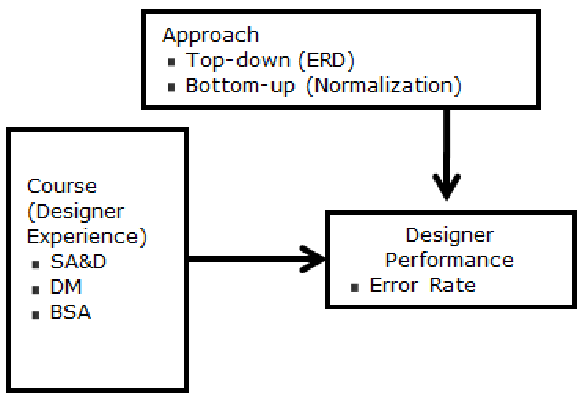


Figure 1: Research Framework

The degree of IS application domain knowledge (e.g., understanding of functional requirements) can potentially affect a designer's ability to design a quality database (Khatri, Ramesh, Vessey, Clay & Park, 2004). The level of database design knowledge is therefore an important indicator of design performance. Subjects in DM and BSA courses have some data modeling experience, while the majority of subjects in SA&D have no such experience. In order to take a DM course, subjects at the studied university had to have completed the SA&D course with a 'C' grade or better. In contrast, BSA is a course for MBA students seeking a concentration in Information Systems (IS). Considering the different levels of database design experience within our subject population, we added "course" as an independent variable to the research framework (see Figure 1).

The hypotheses (presented in null form) addressed in this study are as follows:

H1: No difference in students' performance between the different approaches will exist.

H2: No difference in students' performance across different courses will exist.

H3: No difference in students' performance across different ER modeling constructs will exist.

H4: No difference in students' performance across different relational data model constructs will exist.

4. RESEARCH METHODOLOGY

This study contains two parts. The first part was a laboratory experiment in which subjects were instructed to produce a database schema. The second part required subjects to complete a qualitative survey question, which was used to elicit further information about our subjects' attitudes toward the database design task.

Sample

One hundred and three students enrolled in an undergraduate SA&D and a DM courses, and students enrolled in a postgraduate MBA BSA course completed the in-class exercise. Each undergraduate course had two sections and each section had about the same number of students. Table 1 summarizes the distribution of subjects' demographics.

Table 1: Subjects' Demographics

Course	SA&D	44
	DM	45
	BSA	14
Status	Junior	46
	Senior	43
	Graduate	14
Gender	F	25
	M	78

The SA&D and DM courses are required core courses for the students' study program. The SA&D course is a prerequisite for data management. Most students in SA&D had no prior database design experience. About half of the subjects in the BSA course majored in Information Systems or Computer Science and had taken either one or both SA&D and DM courses in their undergraduate studies.

Procedure

Subjects in each course were exposed to five 75-minute sessions on data modeling processes. In the first session, the instructor explained the purpose of an ERD, including definitions of entity types, relationship, and cardinality. In the second session, the drawing of ERDs from business rules was demonstrated by the instructor and then practiced by subjects. The importance of database normalization was discussed during the third session and normalization techniques to the third normal form (3NF) were demonstrated and practiced in the fourth session. In the fifth session, the instructor explained the value-determined relationship to bridge ER and relational models and applied it to the same examples used in the previous session.

Exercise

In the sixth session, subjects were asked to complete an in-class data modeling exercise. An example of this exercise is presented in Appendix A. After completion of the exercise, subjects answered an open-ended survey question aimed at eliciting their perceptions of the difficulty of the two design approaches.

In the exercise, the top-down approach consisted of students 1) reading a textual description of the domain that identified the applicable business rules; 2) identifying entities; 3) identifying cardinality and relationships; and, 4) drawing a simplified ER diagram without attributes. The top-down exercise is the Step 1 of Appendix A. In the bottom-up condition, students were required to 1) identify domain attributes and consolidate functional dependencies into canonical form based on a given list of domain functional dependencies (FDs); 2) create a normalized relational schema; and 3) draw a final ERD diagram (including attributes) based on relation schemas. The bottom-up is the Steps 2 and 3 of Appendix A. The Appendix B contains the solutions of the top-down and bottom-up exercises. The authors randomly assigned one section of each course to top-down design problem and the other section of each course to bottom-up design problem, and all subjects completed the same problem domain.

Performance (Error Rate)

We operationalized performance as the ratio of incorrect problem domain objects to the total objects of one concept. Thus, for each concept *i*,

$$\text{Performance}_i = \frac{Number\_Of\_Error}{Total\_Object} \quad (1)$$

The in-class exercise was scored according to the number of errors/mistakes in terms of entities, relationships, cardinalities, attributes, normalized relations, and primary keys, with a higher score indicating poorer performance. For example, for the top-down approach, subjects' ERDs should have featured four entities, three relationships, and six maximum cardinalities. The performance is therefore calculated by taking the number_of_error divided by the denominator, thirteen (derived from the sum of four entities, three relationships and six cardinalities). For the bottom-up approach, subjects should have featured four relations: *Patient, Physician, Visit* and *Appointment*. The *Patient* relation has one primary key and four non-key attributes; *Physician* and *Visit* have one primary and two non-key attributes and *Appointment* has two primary keys and one non-key attribute. Therefore, the performance score is determined by the ratio of number of errors to 19 (the denominator 19 was derived form the sum of 14 attributes and 5 primary keys in 4 relations in the third normal form).

5. DATA ANALYSES AND RESULTS

The research design is a 2×3 factorial between subjects and within subjects' methods: their approach (top-down and bottom-up) and the course (SA&D, DM and BSA). Such a design will also reveal whether interactions occur between approach and course (i.e., whether an approach favors a specific level of expertise). IBM SPSS 19 was used to perform the statistical data analysis.

Hypotheses Testing

Hypothesis *H1* predicted that no difference in students' performance between the different approaches will exist. Sixty-seven subjects completed the allocated exercise correctly using top-down approach, while sixty subjects completed the allocated exercise correctly using the bottom-up approach. With zero being the best, Table 2 illustrates that subjects generally produced a higher error rate in the bottom-up design approach (about 19%).

A two-way between-groups ANOVA was performed (see Table 3). The main effect of the approach was not significant (F_2 = .059, p = 0.808). To test the designer performance difference between approaches, we used a paired-*t* test (pair-wise) for each subject. The paired-*t* test procedure compared the means of two variables for a single group, computed the differences between the values of the two variables for each subject, and tested whether the average differed from 0. The mean performance difference between the top-down and bottom-up for each subject was not statistically significant at .05 level (t_{102} =1.225 , p = .223) even though the gap was wider than the between-groups results. Hypothesis *H1* was therefore supported by the between-groups ANOVA and paired-*t* tests that there is no difference in performance between approaches.

Table 2: Error Rate Means of Each Approach Across Courses

	Top-down	Bottom-up	Overall by Course
SA&D	0.311	0.327	0.319
DM	**0.064**	0.112	0.088
BSA	0.082	**0.053**	**0.068**
Overall by Approach	**0.167**	0.192	

Table 3: ANOVA of the Two Factor Factorial Design

Source	Approach	Course	Approach × Course	Error
Type III Sum of Squares	0.005	2.78	0.035	17.077
Df	2	2	4	200
Mean Square	0.005	1.395	0.018	0.085
F	0.059	16.279	0.206	
Sig.	0.808	**0.000**	0.814	

Hypothesis *H2* stated that no difference in students' performance across different courses will exist. Subjects in SA&D, with little experience in data modeling, tended to make more errors than subjects in DM and BSA courses. To test the performance differences between different courses, we ran pair-wise comparisons between courses. The pair-wise comparisons showed that subjects' performance fell into two clusters. Subjects' performance in DM and BSA had no significant difference. Subjects in SA&D fell into another cluster that was significantly different from DM and BSA (see Table 4). Although the approach-course interaction plot (Figure 2) showed some sign of interactions between the two factors, the ANOVA results showed otherwise (F_4 = .206, p = .814).

Subjects in BSA had the lowest error rate across all three courses, while subjects in SA&D had the highest error rate. Our results therefore support the notion that previous database design experience had a significant effect on subjects' task performance. *H2*'s prediction that no performance difference will exist between different courses is therefore rejected (F_2 = 16.279, p = .000) (see Table 3).

Table 4: Pair-wise Comparisons between Courses

Course (I-J)	Mean Difference (I-J)	Std. Error	Sig.
SA&D—DM	0.248	0.055	**0.000**
SA&D—BSA	0.229	0.08	**0.005**
DM—BSA	-0.019	0.079	0.814

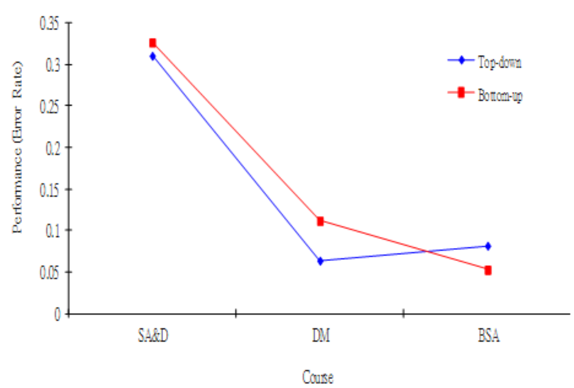


Figure 2: Approach—Course Interaction Plot

The means were plotted on a graph (Figure 2). Subjects in the BSA course produced lower error rates in the bottom-up approach. The overall average error rate of the top-down (16.7%) and bottom-up approaches (19.2%) indicated that the using bottom-up approach resulted in a slightly higher error rate than using the top-down approach.

Hypothesis *H3* stated that no difference in students' performance across different ER modeling constructs will exist. The three concepts tested were: entity, relationship, and cardinality. In the top-down approach, the performance of all three concepts had significantly different paired-*t* values (see Table 5). Entity was the easiest concept to grasp. The overall mean error rate of entity was 9 percent. The most difficult concept was cardinality. The overall mean error rate of cardinality was 34 percent. Relationship was in the middle with 15 percent error rate. Hypothesis *H3* was rejected because the error rates for all three ERD concepts were significantly different from one another.

Table 5: Paired *t*-test—Concepts Performance in Top-down Approach

	t	DF	P-Value
Entity vs. Relationship	-3.14	102	**0.002**
Entity vs. Cardinality	-4.981	102	**0.000**
Relationship vs. Cardinality	-4.04	102	**0.000**

Hypothesis *H4* posited that there will be no difference in students' performance across different relational data model constructs. Table 6 displays the paired t-test results. In the bottom-up approach, subjects had lower error rates in decomposing relations *Patient* and *Physician*. Subjects had higher error rates in decomposing Relations *Visit* and *Appointment*.

Table 6: Paired t-test—Concepts Performance in Bottom-up Approach

	t	DF	P-Value
Patient vs. *Physician*	-0.33	102	0.741
Patient vs. *Visit*	-3.79	102	**0.000**
Patient vs. *Appointment*	-2.86	102	**0.005**
Physician vs. *Visit*	-3.86	102	**0.000**
Physician vs. *Appointment*	-2.72	102	**0.008**
Visit vs. *Appointment*	-0.26	102	0.795

The relation *Appointment* had a composite key that made it an associative entity in the ER model which requires higher-level of understanding. Hypothesis *H4* was rejected since all four relation concepts in the bottom-up approach are significantly different from each other.

Overall Performance: Top-down vs. Bottom-up

A general overview of subjects' performance of the in-class exercise was shown in Table 2. The means of performance of the two factors were calculated. The lower means of error rates are shown in bold and underlined.

Table 7: Concept Performance of the In-Class Exercise

Concepts (Top-down)	Mean	Concept (Bottom-up)	Mean
ERD (Overall)	0.167	Normalization (Overall)	0.192
Entity	0.09	Relation *Patient*	0.151
Relationship	0.149	Primary Key	0.185
Cardinality	**0.342**	Non-key Attribute	0.146
		Relation *Physician*	0.154
		Primary Key	0.194
		Non-key Attribute	0.142
		Relation *Visit*	0.25
		Primary Key	0.233
		Non-key Attribute	0.259
		Relation *Appointment*	**0.254**
		Primary Key	0.204
		Non-key Attribute	0.291

The subjects' demonstration of different concepts in the two approaches is shown in Table 7. The most error-prone concept in each approach is shown in bold and underlined. Subjects had more errors in assigning correct cardinalities using the top-down approach. Cardinality was the most difficult concept to master for most subjects. The subjects created more errors in the relation *Appointment* in the bottom-up approach. The relation *Appointment* was an associative entity, had a composite key, and was the most difficult concept to master in the bottom-up approach. Relations *Patient* and *Physician* had the lowest error rates since most subjects could relate those to their real-world experiences.

In the top-down approach, the performance of all three concepts, entity, relationship, and cardinality, had significantly different paired-*t* values (see Table 5). Entity was the easiest concept to grasp. The most difficult concept was cardinality. The difficulty level of relationship was medium. This result highlights the needs that database educators should ensure that the concepts of cardinality and relationship concepts are well explained and understood by students.

In the bottom-up approach, subjects had lower error rates in decomposing relations *Patient* and *Physician*. Subjects had higher error rates in decomposing relations *Visit* and *Appointment*. The relation *Appointment* had a composite key that made it an associative entity in the ER model. The combination of associative entity and composite key made it the most difficult concept to master in the bottom-up approach because of its complexity. This emphasizes the importance that database educators should ensure that concepts of associative entity and the composite key are understood by students.

Phase 2: Qualitative

Following the quantitative laboratory experiment (Phase 1), an open-ended question was used in Phase 2 to collect subjects' perspectives. Subjects were to give their opinions on which approach and concept were more difficult to learn/master. Forty-seven subjects answered the question: five subjects considered both approaches were easy, 10 said both approaches were difficult, 11 thought ERD was difficult, and 21 indicated normalization was difficult. Combining qualitative and quantitative approaches to this study, we intended to triangulate findings to find contradictions and new perspectives. In general, the qualitative results supported the quantitative analyses.

6. CONCLUSIONS AND LIMITATIONS

This study has several limitations. The use of students as subjects from a single university is always an issue in terms of the ability to generalize findings. The second limitation was the time constraint to complete the experiment in six 75-minute sessions, which limited the training time for the two database design approaches.
The experiment looked at two factors: approach and course (previous experience). The results indicated that experience has higher impacts on students' performance than approach. We did not find statistically significant difference between approaches. No significant interaction effect between the approach and course was found. Overall, the subjects in BSA had the lowest error rates. Looking into each approach, we found the subjects in BSA performed best using the bottom-up approach, and DM was the best in top-down. For individual courses, the subjects in DM and SA&D had the same overall approach ranking pattern (better in top-down), opposite of the BSA results. This indicated that with proper training/experience subjects could do better in bottom-up design approach. The most error-prone concepts in each approach were cardinality in top-down, and associative (transaction) relation/table in bottom-up.

The need for training designers in data modeling becomes more important due to the growth of database usage in the business world. Effective teaching of data modeling is one of the important issues/challenges for IS/IT educators. Novice designers are likely to make errors, and design flaws can lead to significant costs in the maintenance phase. This study proposed to examine the relationship between top-down and bottom-up design approaches and the error-prone concepts in each design approach. The results indicated that top-down design led to lower error rates for most cases but the bottom-up design sometimes outperformed when designers were equipped with adequate experience. Not all concepts in every design approach have the same level of difficulty. This study results suggest that IS educators should allocate enough time to teach the concepts of cardinality, associative entity/table, and composite key for database.

7. REFERENCES

Bernstein, P. A. (1976). Synthesizing third normal form relations from functional dependencies. *ACM Transactions Database Systems,* 1, 4, 277-298.

Chen, P. P. (1976). The entity-relationship model — Toward a unified view of data. *ACM Transactions on Database Systems*, 1(1), 9-36.

Codd, E. F. (1970). A relational model of data for large relational databases. *Communications of the ACM*, 13 (June), 377-387.

Connolly, T., & Begg, C. (2000). Database Solutions. A step-by-step guide to building databases. Harlow, England: Addison-Wesley.

Fotache, M. (2006). Why normalization failed to become the ultimate guide for database designers? Available at SSRN: http://ssrn.com/abstract=905060 or http://dx.doi.org/10.2139/ssrn.905060

Hoffer, J. A., Ramesh, V., & Topi, H. (2010). Modern database management. 10th Ed., Prentice-Hall, Upper Saddle River, NJ.

Khatri, V., Ramesh, V., Vessey, I., Clay, P. & Park S. (2004). *Comprehension of conceptual schemas: exploring the role of application and IS domain knowledge*, Working paper.

Philip, G. C. (2007). Teaching database modeling and design: Areas of confusion and helpful hints, *Journal of Information Technology Education*, 6, 481-497.

Rob, P., & Coronel, C. (2004). Database systems: design, implementation, and management. Course Technology, Boston, MA.

Shoval, P., Danoch, R., & Balabam, M. (2004). Hierarchical entity-relationship diagrams: The model, method of creation and experimental evaluation, *Requirements Engineering*, 9(4), 217-228.

Teory, T., Wei, G., Bolton, D., & Koenig, J. (1989). ER model clustering as an aid for user communication and documentation in database design, *Communications of the ACM,* 32(8), 975–987.

Topi, H., Valacich, J., Wright, R., Kaiser, K., Nunamaker, J., Sipior, J., & De Vreeda, G. (2009). IS 2010: Curriculum guidelines for undergraduate degree programs in Information Systems, *Communications of AIS*, 2009, 359-428.

Appendix A: Data Modeling Exercise

The information on this page relates to designing a database that stores information for a medical clinic. You will need to develop a data model using the top-down design approach (Step 1) and bottom-up approach (Steps 2 and 3).

1) Draw a simple Entity-Relationship diagram (ERD) (without attributes) that reflects the following business rules that were provided by your client:

   A patient, over time, may make many visits to the clinic, and each visit relates to a single patient. Each visit, which is allocated a unique visit number, may involve many appointments, with each appointment related to a single visit. A physician may deal with many appointments, and each appointment is dealt with by a single physician.

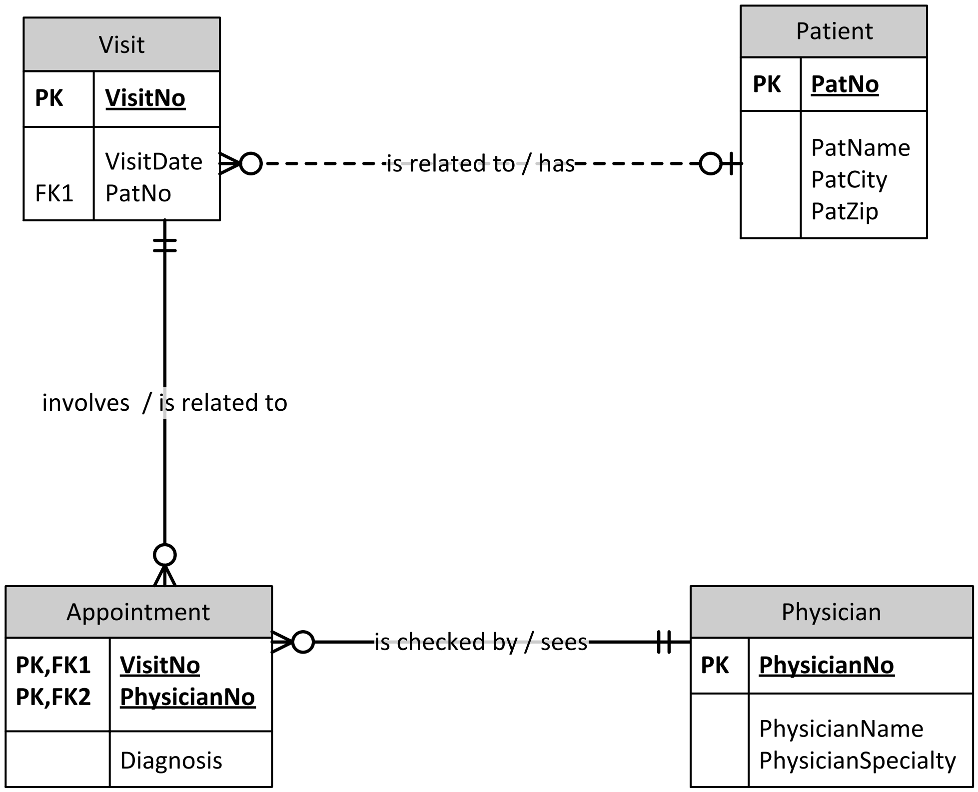
2) An experienced DBA inspected the sample data and identified the universal relation Clinic and functional dependencies (FDs). Your task is to normalize the universal relation Clinic to the third normal form (3NF). Show your answer in relation format.

   Universal Relation:
   Clinic (<u>VisiNo, PhysicianNo</u>, VisitDate, PatNo, PatName, PatCity, PatZip, PatPhone, PhysicanName, PhysicianSpecialty, Diagnosis)

   FDs:
   VisitNo, PhysicianNo → VisitDate, PatNo, PatName, PatCity, PatZip, PatPhone, PhysicianName, PhysicianSpecialty, Diagnosis
   PhysicianNo → PhysicianName, PhysicianSpecialty
   VisitNo → VisitDate, PatNo, PatName, PatCity, PatZip, PatPhone
   PatNo → PatName, PatCity, PatZip, PatPhone

3) Draw an ER diagram (with attributes) from Step 2.

Appendix B: Exercise Solutions



Patient (**PatNo**, PatName, PatCity, PatZip, PatPhone)
Physician (**PhysicianNo**, PhysicianName, PhysicianSpecialty)
Visit (**VisitNo**, VisitDate, PatNo)
Appointment (**VisitNo**, **PhysicianNo**, Diagnosis)

Using Mobile Apps to Entice General Education Students into Technology Fields

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Abstract

It is of national importance to increase the number of college students pursuing degrees in information systems/information technology (IT/IS) subjects. The primary focus at many institutions is renovating or enhancing existing IT/IS programs and the target audience is the students who have selected to major in IT/IS subjects. This paper looks at general education students and how exposure to mobile app development may change their attitudes toward IT/IS and entice them into pursuing a technology major or minor. The research setting is a liberal arts university with a large female population and a diverse ethnic basis. The authors develop a new pedagogical strategy, teaching students to develop mobile apps using an easy-to-use tool, with the objective of transforming students from technology consumers to technology creators and increasing the number who choose technology as a career path. Techniques for the evaluation of the project outcomes are also discussed.

Keywords: mobile apps, general education, computational thinking, technology consumer, technology creator

1. INTRODUCTION

In a 2010 December report, IDC (one of the leading market research firms) predicted that app-capable, non-PC devices would out-ship PCs within 18 months (IDC, 2010). In essence, IDC concluded that this is the end of the personal computer era and the beginning of the mobile age. In September, 2011, Salesforce Chairman and CEO Marc Benioff asked Eric Schmidt, the Executive Chairman of Google, to discuss the industry's future. Schmidt commented, "…the next game changing shift will comprise mobile, local and social technologies and will create an environment that unfolds in true real-time…" (Salesforce, 2011). As education professionals, this prompted us to reexamine and rethink whether understanding these technologies could help us attract more students into considering technology as a career or, at a minimum, to help them see the value of technology development in another field such as science or mathematics.

As technology becomes an essential part of everyone's lives in the global economy, it is critical for the U.S. to increase the number of STEM (Science, Technology, Engineering, and Mathematics) workers, male and female, who adopt technology as a career or who can apply technology effectively in another STEM field. In contrast, much evidence suggests that fewer students are leaving high-school with the intention of pursuing a STEM career (Carnevale, Smith, & Melton, 2011). Many of them are entering college as undeclared majors or lacking a strong conviction to the major they have selected. Can they be influenced as they enter college or even in the latter stages of high school? If the answer is yes, how and what strategy and method do we use? One motivation of this study is to answer these questions and solve the puzzle.

MIT professor Seymour Papert's seminal book Mindstorms (Papert, 1993), took the education world by storm over thirty years ago. Surprisingly, most college students (especially incoming freshmen) still equate information technology (IT) to simply computers or computer programming. Subjects like IT or computer science (CS) has become the realm of "geeks" and one of the popular misconceptions is that all programming is difficult, tedious, and requires high levels of mathematics proficiency.

"We carry powerful computers in our pockets, our social networks and interactions are increasingly computer-mediated and online and offline lives are increasingly fused. That's the world that young people need to understand, and that's the technology with which they should be empowered" (Abelson, 2011). The ensuing question is how we, as educators, respond. As IT/IS faculty members, we believe it is our responsibility to create an environment that encourages students to use computers or computing devices in the constructionist way that Papert envisioned – students creating computer applications and acquiring "a sense of mastery over a piece of the most modern and powerful technology" and through this endeavor establishing "intimate contact with some of the deepest ideas from science, from mathematics, and from the art of intellectual model building" (Grover, 2010; Papert, 1993 p. 5).

In her widely-cited article Computational Thinking, Wing (2006) argued that "computational thinking is a fundamental skill for everyone, not just for computer scientists" (p. 33). Building on this theoretical pillar, we propose to teach mobile apps development courses to reach the general education audience, inspire their interests in technology, and change their image of the computing field. Furthermore, the project reflects the broader goals of computational thinking for delivery to general education students. It is believed that students today have embraced the use of technology (as consumers), particularly mobile technology, and that building mobile apps (as creators) could be the hook into a broader understanding of the contributions they can make in the technology field. Our ultimate goal is to let students recognize computational thinking as one of the fundamental skills in their daily lives and to motivate them to be active participants in creating the technology used in their world.

"The recent push for nurturing creativity and problem solving skills as essential 21st century skills provides weight to the rationale for exposing youth to the art – and joy – of programming. Youth as 'creators' not 'consumers' is the mantra of progressive pedagogues…" (Grover, 2010). "…logic and reasoning skills as well as the ability to leverage technology to get things done quickly, efficiently, and in a completely individualized way" are the important skills for today's students (Dawson, 2010). We will use the general education courses as a platform to teach students these skills.

We structure the rest of the article as follows: in the next section, we introduce the research context. Then, we elaborate the major objectives of the study and illustrate how we are going to implement the new courses. We will present the evaluation methodology and process. The paper concludes with a discussion of the major contributions of implementing the new courses and the broader impacts of this research.

2. RESEARCH BACKGROUND

The authors work for a small liberal arts college with a diverse student population of approximately 3,500 undergraduate and graduate students (74% female, 15% African American, 13% Hispanic, and 8% Asian/Pacific Islander). Many students are working professionals, one-third of the students are first-generation college students, and transfer students from community colleges comprise almost one-half of the undergraduate population. The university is a student-centered learning community that has long placed a high priority on quality science, technology, and mathematics education, a commitment evidenced by the new state-of-the-art science building which substantially increases laboratory space and features state-of-the-art scientific and technology equipment.

In 2008, the integration of undergraduate research with education at the university was strengthened through the establishment of the DISCOVER Center for Undergraduate Research. The mission of the Center is to promote student engagement in the University learning community, as well as to develop a broader national and international community of learners, through research, creative work, and inquiry learning. Under this initiative, a part of the general education curriculum, freshmen students take a three-credit first year seminar, DSC 101, and entering transfer students take DSC 201, a one-credit course, in which they are exposed to inquiry learning and begin to develop or refine their research skills. This program forms the foundation for this study.

The purpose of this project is to use "mobile application (app) development" to increase the number of general education students who see technology as a career objective even though they may come to college with either an undeclared or in a non-IT/IS major, most often selected based on their success in a specific non-IS high school topic. Furthermore, the project reflects the broader goals of computational thinking for delivery to general education students. We hope the proposed program will prepare non-IT/IS students with substantial competencies and inspire them to participate in the computing field, in college and later as a career. The mobile apps courses will be essentially incorporated into the DISCOVER program and offered to any undergraduate students in their first semester at the university.

We design, develop, implement, and evaluate a series of new, inquiry-based mobile technology courses. Through the creation of mobile apps for an Android smartphone, the students will discover the direct application of technology to their lives as well as experience their role in creating it. By teaching the students how to use a simple and accessible development tool (i.e., App Inventor) in a creative and useful way, students will be encouraged to re-imagine the technology world and to explore it, not as consumers but as creators. Freshman, transfer students, and repeating students will all take these classes.

3. CREATING AND IMPLEMENTING THE MOBILE APPS COURSES

Project Objectives

We will extend the creation of mobile apps in IT/IS-related subjects to a broader audience in general education and provide a formal assessment of the impact of the creation of meaningful technology courses on general education students. The program will provide an opportunity for students to use a required inquiry course (DISCOVER) in our university's general education program to explore the development of mobile apps (a common phenomenon in their young lives). A series of courses will be taught over a two-year period to a variety of students, followed by a formal assessment of learning outcomes and the impact of these courses on the students' confidence level in technology.

In developing the courses and assessing their impact on students, we make use of the theoretical framework from the CS Principles project funded by NSF and the College Board which focused on developing an AP (Advance Placement) course to "broaden participation in computing and computer science." (http://csprinciples.org). The six computational thinking practices established by the College Board: connecting computing, developing computational artifacts, abstracting, analyzing problems and artifacts, communicating, and working effectively in teams (The College Board, 2011) will be part of the course design and subsequent assessment.

The first specific objective of the research project is to expose a wide variety of general education students to mobile app development in a variety of settings to raise the level of awareness and appreciation of technology as well as expose them to "what is behind the scenes of technology" (connecting computing). The techniques to reach these students include direct teaching in general education courses for initial freshman and transfer students; direct teaching for freshman who had some barriers to learning and who failed the initial Discover course with another topic; teaching by other faculty members where mobile app development is integrated as part of another science, applied science, mathematics, or applied mathematics course in the general education program; mobile apps taught as part of the topics in MIS/IT introduction level course for business students; and as taught as part of a summer school institute for high school students.

Second, we aim to convert the students from their traditional role as technology consumers to technology creators (developing computing artifacts) by:

(i) Increasing the level of confidence in students to analyze problems and develop mobile apps to solve problems independently (analyzing problems and artifacts) and inspire students to participate in a technology field;

(ii) Improving personal problem solving ability (abstracting) and cultivate the students' ability to integrate knowledge and skills across different fields (connecting computing) particularly for students who may have not been previously academically successful; and

(iii) Improving students' communication skills in a team setting, particularly when talking about technology (communicating and working effectively in a team).

How We Implement The Courses

The mobile apps development courses will be offered to incoming freshmen and transfer students. These courses will expose general education students with different academic backgrounds and interests to some of the foundational elements of computing. The ultimate goal of the project is to research, develop, and recommend ways to improve the recruiting of students in the technology field, even if they did not see themselves as "technologists". Special attention will be paid to underrepresented groups in the technology field including women, minorities, Veterans, and students with barriers to learning.

The following student populations will be targeted over a two-year time frame:

- Incoming freshmen and transfer students who self-select their DISCOVER course based on a short description of the mobile apps focus;
- Freshmen and transfer students who must repeat the DISCOVER course because they failed in the first attempt;
- Freshmen students who self-select a course based on a topic other than mobile apps but where mobile app development topic is included in the courses and whose faculty have been trained in mobile app development;
- Freshmen or sophomore students who have selected a "business major" and who have taken a DISCOVER course in their first semester without mobile app development and take a required IT/IS course in their major; and
- High school students who might not be considering a IT/IS major in college, including rising juniors and seniors.

The timeline for the proposed program for the two-year period of performance is presented in Appendix: Figure 1.

DISCOVER Course for Freshmen and Transfer Students

The DISCOVER program has a required syllabus which allows for students to be exposed to the University expectations, events, and services, as well as for each faculty member to develop their own content in their designated subject area.
In the designated DISCOVER series of courses, students will learn how to create their own mobile apps using MIT App Inventor, a visual, web-based programming environment widely used at the college level. Previous programming experience is not a prerequisite. By teaching students how to design and implement mobile apps, the aim is to transform their role, or at least perspective, to one of technology creators rather than just technology consumers. The hands-on laboratory work and inquiry-based individual and group projects will improve students' problem-solving skills, impart up-to-date knowledge of technology, promote critical and creative thinking, information organization and management, and develop effective communication skills and teamwork. Early exposure to these fundamental elements of computational thinking will lead students to a better sense of their own interests in the technology field or beyond (Grover, 2009).

Working individually and in small teams, students will use an Android platform phone and App Inventor tool to build any app they want to imagine such as a game, a personal convenience app, an app to help people communicate, or an app that talks to web services like Twitter. For example, one English major student from the University of San Francisco created a mobile app called No Texting While Driving. The text "I'm driving right now. I'll contact you shortly" is sent in response to all texts while this app is running. Another example is the "Haiti Commodity Collector" mobile app created by a group of students from Trinity College and Wesleyan University. This app allows agronomists to track prices of commodities among various Haitian markets so they know where to buy food for humanitarian food assistance during crisis response. The unique feature of the program is that students can and will enthusiastically share their class work with friends and family, thus reinforcing their computational thinking skills. In addition to learning how to create an application and become better problem solvers, this course also allows students to explore the exciting world of information technology from the perspective of mobile computing and its increasingly important effect on society.

It is noted that students will enroll with varying degrees of expertise in and comfort with the use of technology. Projects will need to be interesting and complex enough to challenge those who are proficient with technology while not leaving behind students who are less accomplished in its use.

DISCOVER Courses for Students with Barriers to Learning

Freshman who have failed the mandatory DISCOVER course in the fall semester are required to take the course again in the spring semester. As they will not need the level of "freshman orientation" that is built into the freshman course, there will be more time to address learning skills and to implement the active learning component of the course. Based on their knowledge of the barriers to learning with this population, the authors will modify the original course to reflect a different pace and additional support, whether it be in writing, in technology, or in learning skills. One of the authors will teach the course with a peer mentor from the university's Center for Teaching and Learning.

Summer Institute for High School Students

Our university offers a Summer Institute for local and international high school students and we will offer a mobile apps development session in subsequent years. The target audience is teenagers and young adults who have not been exposed to high-quality STEM programs in schools or are at a community college and want to explore technology applications further. The course will provide hands-on experience to show them that, unlike many existing stereotypes, “STEM subjects can be fun to study and can lead to career paths that are exciting and fulfilling, as well as practical” (Ferrante, 2011).
The experience with this population of future college students will also facilitate the refinement of the freshman and transfer student DISCOVER course for later semesters.

Business IT/IS Course Changes

The authors currently teach a service course for incoming undergraduate business students to cover the uses of technology in business and society. The broad purpose of the course is to explore the role of computers in this global age and understand how computers are used in business and in global society. For example, students should become more aware of the prominence of social media and the growing ethical implications of the use of technology, including the potential impact it can have on individual privacy. We have previously transformed the original curriculum to include social media and video technology topics. Following the same strategy, the mobile apps development component will be integrated into this service course with a primary focus on the development of "business" apps. The target audience will be the freshmen and sophomores from the business school who have taken a different DISCOVER course.

4. EVALUATION OF PROJECT

A variety of techniques will be used to assess the students. The logic model is shown as in Appendix: Figure 2.

The sample size is 450 students. The populations will be assessed throughout the project and a formal assessment will be made at the end of the period of performance,

Each course will be closely assessed including:

- A pre- and post-survey to ascertain students' attitudes and confidence levels with technology and mobile apps, in particular;
- A knowledge assessment based on one or more tests and projects to assess the students’ knowledge learning gains;
- Participation in public display of the mobile apps (presentation of team projects in class, student research conference, mobile apps competition, etc.) to assess confidence levels, team work, and communication skills;
- A skills assessment based on a project which will determine whether the students have learned the appropriate computational skills, including the ability

to analyze a problem, abstract the solution and create a mobile app artifact; and
- A student evaluation of the overall course.

In addition, the courses will be subject to the assessment process used for all DISCOVER courses. The pre- and post-survey instruments will be taken by all students enrolled in these courses. The impact design will be a randomized controlled trial where DISCOVER courses which do not involve any technology use, DISCOVER courses which incorporate some technology (e.g. video production), and the mobile app course outcomes will be compared. Of particular interest is the comparison of the courses taught by faculty members before their adoption of the mobile app model.

The results will be collected and analyzed by the university's Office of Institutional Effectiveness at the end of each semester. Feedback will be provided to the faculty on each course and the cumulative results of the assessments.

Formative Evaluation

On-going, periodic evaluation of project activities is critical to achieving program excellence. The formative evaluation will be used to:

- Actively engage all DISCOVER mobile apps course participants in a reflective process to generate feedback on their learning gains;
- Document key stages in the educational process; and
- Provide structured evidence for program planning and adjustments.

The formative assessments with students will be distributed after the first month in the program and at the end of each month. We will use the responses to take necessary actions either to support the individual student or to strengthen the overall program.

Summative Evaluation

The summative evaluation will assess the overall effectiveness of the program in meeting the stated objectives as specified above. To that end, the following are proposed:

- The summative evaluation will be performed by University's Office of Institutional Effectiveness;
- The summative evaluation will examine the success of the program in meeting the program objectives; and
- A variety of techniques will be used to collect information, including direct and indirect measures.

At the end of the study additional data analysis will be performed to determine:

- Whether the course increased the entry into a technology track either in high school, as freshmen or as transfer students;
- Whether the course significantly affected the attitude of students towards technology and whether there were any factors in their background that correlated with their change in attitude or lack of attitude change, such as gender, high school GPA, high school course selection, technology availability and use, etc.;
- Whether the course made a difference in learning for struggling students;
- Whether the learning gains were greater in the mobile apps development courses as opposed to the other DISCOVER courses; and
- Whether a student with a specific major (such as business) is more likely to be influenced into a technology career than other students in the general student population.

5. CONCLUSIONS

The project has one main objective: to increase the number of students who consider a future career in technology. Our intention is to use the mobile app platform as a pathway to intrigue and inspire general education students to explore the exciting world of IT/IS. By teaching them how to create computer applications that meet various social needs and could be shared with friends and families, the project exposes the students to inquiry learning and computational thinking. To evaluate the impact of the program, student learning gains including computational thinking ability and their confidence level with technology will be formally assessed.

6. REFERENCES

Abelson, H. (2011). Mobile Ramblings. *EDUCAUSE Quarterly 34*(1).

Carnevale, A. P., Smith, N., & Melton, M. (2011). STEM: Executive Summary: Georgetown University: Center on Education and the Workforce.

Dawson, C. (2010). Google App Inventor: Slick tool for schools. *ZDNet Education*. Retrieved from http://www.zdnet.com/blog/education/google-app-inventor-slick-tool-for-schools/4112

Ferrante, E. (2011). Mobile Action Lab Trains Young People to Design, Develop and Market Apps. Retrieved from http://nsf.gov/discoveries/disc_summ.jsp?cntn_id=119430&org=NSF

Grover, S. (2009). Expanding the Technology Curriculum to Include Foundational Elements of Computer Science for K-8 *Learning & Leading with Technology, ISTE 37*(3).

Grover, S. (2010). Computational Thinking, Programming…and the Google App Inventor. *Kids and Technology,* (August 3, 2010). Retrieved from http://www.thesmartbean.com/magazine/children-technology-magazine/computational-thinking-programming-and-the-google-app-inventor/

IDC. (2010). IDC Predicts Cloud Services, Mobile Computing, and Social Networking to Mature and Coalesce in 2011, Creating a New Mainstream for the IT Industry. *IDC - Press Release*. Retrieved from http://www.idc.com/getdoc.jsp?containerId=prUS22593310

Papert, S. A. (1993). *Mindstorms: Children, Computers, And Powerful Ideas* (2nd ed.). New York: Basic Books, A Member of The Perseus Books Group (First Edition, 1980).

Salesforce (2001, September 1). Marc Benioff and Eric Schmidt at Dreamforce 2011. Retrieved March 6, 2013 from http://www.youtube.com/watch?v=JD15hb0XbfY.

The College Board. (2011). *Computer Science: Principles-Course Annotations*. Retrieved from http://www.csprinciples.org/home/about-the-project

Wing, J. M. (2006). Computational Thinking. *Communications of the ACM 49*(3), 33-35.

Appendix

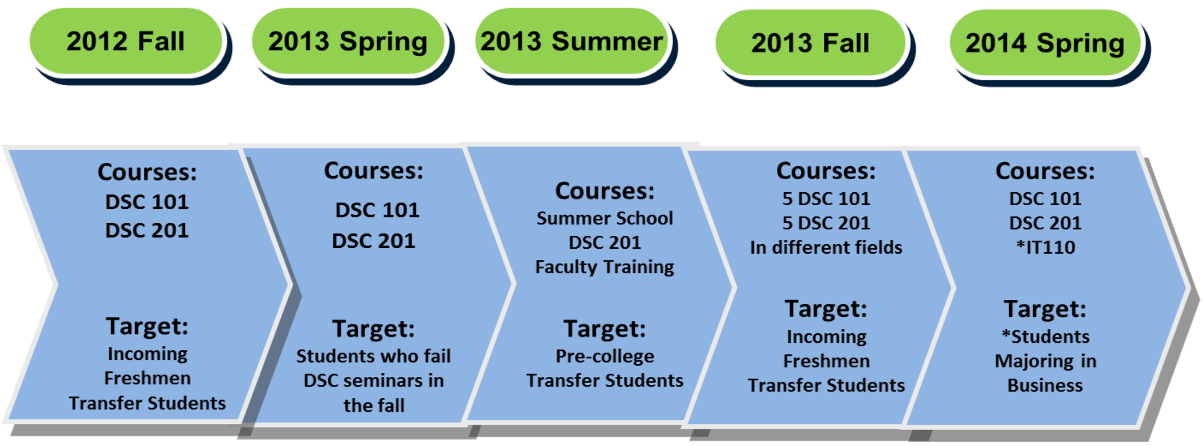

Figure 1. The timeline for the program

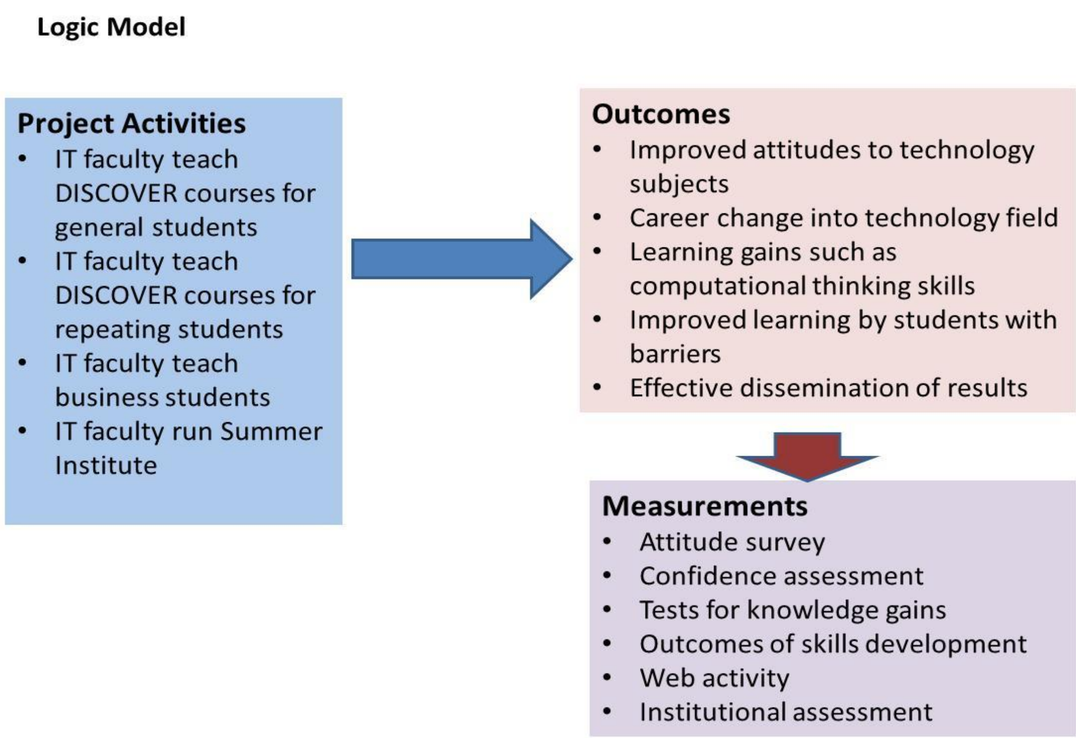

Figure 2.The Logic Model for the Project Assessment

Developing a Bachelor's Program in Health Information Technology

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Abstract

There is little doubt that the healthcare industry is experiencing tremendous growth in regards to technology. If you have visited a healthcare professional recently, you may have seen a similar notice, "Please be patient as we implement a new electronic healthcare record system." This confluence of technology and healthcare provides a new field of study in IT – Health Information Technology (HIT). This paper describes the development and implementation process and the curriculum for a Bachelor of Science in Information Technology with a major in Health Information Technology. Developed in collaboration with nursing educators and in consultation with HIT professionals, this unique multi-disciplinary program blends technology and healthcare to prepare students for a wide variety of opportunities in the evolving field of HIT. The development of this degree was funded in part by a grant awarded under ARRA High Growth & Emerging Industries Grant as implemented by the U.S. Department of Labor's Employment & Training Administration.

Keywords: health information technology, HIT, curriculum development, EHR, +2 degree

1. INTRODUCTION

Nationwide, there is a significant focus on healthcare and technology that will only grow in future years. Mandates from the federal government that began with the Bush administration and continued by the Obama administration indicate that a strong push will be made to align technology and healthcare. The federal government has also provided economic incentives for the adoption of health information technology through programs from the Health Information Technology for Economic and Clinical Health Act (HITECH Act) of 2009 (HITECH, 2011). Experts estimate that up to 200,000 new jobs will be created in the Health

IT sector (Gonsalves, 2010). According to a study conducted by the University of San Diego Extension, the top job of hot careers is "Healthcare Information Technology - As technology increases, so does the need for health information technicians to use and maintain patient data that is vital for quality healthcare and to keep all medical records organized and confidential. Technicians are needed for emerging jobs, such as healthcare integration engineer, healthcare systems analyst, clinical IT consultant, and technology support specialist." ("Health IT No. 1 List," 2011) The Bureau of Labor Statistics projects a 29% increase in jobs in the healthcare area as well as an average increase in Computer Occupations of 22% ("Overview of 2010-2020 Projections," 2012). Within Computer Occupations, healthcare IT needs are specifically mentioned in Network and Computer Systems Administrators with a projected 28% increase ("Network and Computer Systems Administrators," 2012) and for Software Developers with a projected increase from 28-32% ("Software Developers," 2012).

Much of the demand for HIT professionals stems from the adoption of the Electronic Health Record (EHR) by hospitals and healthcare provider offices. According to the U.S. Department of Health and Human Services, the "percentage of U.S. hospitals that had adopted EHRs has more than doubled from 16 to 35 percent between 2009 and 2011. And, 85 percent of hospitals now report that by 2015 they intend to take advantage of the incentive payments made available through the Medicare and Medicaid EHR Incentive Programs." (HHS Secretary Kathleen Sebelius, 2012).

Although the current focus of HIT is EHRs, technologies such as robot assisted surgery, health care analytics, and personalized medicine based on bioinformatics will sustain and increase the demand for HIT professionals. At the same time, solutions to many current health care policy discussions such as cost containment, outcomes, and effectiveness will involve HIT. These trends indicate that there will be a growing need for HIT professionals.

HIT is not just about the use of information technology in healthcare. To support the growing use of IT in healthcare, employers are looking for students who can work with the new technologies that are being deployed but also understand the world of medicine and health care. This offers an opportunity to provide degrees that develop skills in both of these fields. Additionally, the universal need for health care, combined with local nature of health care delivery, offer educational institutions an opportunity to develop programs that serve their local communities.

It is clear that the emerging technology needs of healthcare provide us with an opportunity to launch a field of study in Health Information Technology. This paper describes the development and implementation process and the curriculum for a Bachelor of Science in Information Technology with a major in Health Information Technology. Developed in collaboration with nursing educators and HIT professionals, this unique multi-disciplinary program blends technology and healthcare to prepare students for a wide variety of opportunities in the evolving field of HIT. The development of this degree was funded in part by a grant awarded under ARRA High Growth & Emerging Industries Grant as implemented by the U.S. Department of Labor's Employment & Training Administration.

The remainder of the paper is organized in five sections. We begin by outlining the curriculum development process. We describe the course curriculum and new course development. After describing the curriculum we explore the process we used to select an Electronic Health Record system. Lastly, we explain other implementation details and conclude by summarizing other successes and challenges.

2. CURRICULUM DEVELOPMENT PROCESS

The Computing and Information Technology (CIT) Department at Miami University is uniquely positioned to offer a program in Health Information Technology as it is housed in the same academic division as the Nursing Department. The CIT Department, the Nursing Department, and industry professionals worked together to create an academic program which is timely and relevant to the local community and the State of Ohio. This degree provides additional educational opportunities for students in technology or healthcare, those earning associate degrees from local community colleges, and working professionals. With the recent changes under the University System of Ohio's (USO) strategic plan, the primary mission of the regional campuses is no longer a focus on only associate degrees and the first two years of a baccalaureate degree. The mission has instead expanded toward increasing the number of baccalaureate degree programs, especially those that are completion degree programs.

Faculty members from both the CIT and Nursing Departments formed the HIT Subcommittee where we designed a +2 baccalaureate completion degree that would appeal to students with an associate degree (or background) either in IT or healthcare.

Involving HIT Professionals

Area HIT professionals played a significant role during the entire development process. Immediately after forming, the HIT Subcommittee held a meeting with local HIT professionals and faculty from area community colleges to brainstorm on the set of skills and knowledge that a graduate of an HIT program would need. With this list of skills, the HIT Subcommittee designed a draft curriculum that included not only courses focused on IT but also courses in Nursing, Anatomy and Physiology, and liberal education. The HIT professionals reviewed the draft curriculum, met with members of the HIT Subcommittee, and made suggestions for improvement. HIT professionals also contributed to the development of the two courses that focus specifically on Health IT (HIT I and HIT II), outlining suggested topics for the courses and reviewing course proposals. The first time that the HIT I (CIT 431) and HIT II (CIT 432) courses are offered a HIT professional will team-teach with a CIT faculty member.

Approval Process – A Team Approach

Since this would be the first time that Miami University would offer a Bachelor of Science in Information Technology, the state approval process was extremely detailed. Including appendices, the proposal was over 400 pages in length. Members of the HIT Subcommittee prepared sections of the proposal and met weekly to review the sections. These sections not only included the proposed curriculum but also topics such as assessment, regional accreditation, needs assessment for degree, job prospects for graduates, university support infrastructure, administrative organization, syllabi for all courses in the degree program, projected number of students, curricula vitae for all faculty members, and budget. When the proposal was completed, it was reviewed and approved by the following:

- CIT Department
- Academic Division
- Council of Academic Deans
- University Senate Undergraduate Curriculum Committee
- University Senate
- University Board of Trustees
- State of Ohio

Health Careers Collaborative & DOL Grant

The program discussed in this paper was funded in part by ARRA High Growth & Emerging Industries Grant as implemented by the U.S. Department of Labor's Employment & Training Administration. Miami University worked with Cincinnati State Technical and Community College as part of a larger effort titled the Health Careers Collaborative (HCC) of Greater Cincinnati to create an educational pathway for students interested in careers in HIT. New programs were developed so that students can earn an associate degree in HIT from a local community college and then move seamlessly to a bachelor's program in the same area. Partners of the HCC include area hospitals, community colleges, regional campuses, and community-based organizations. The connections that were possible because of this grant repeatedly proved to be valuable. For instance, at one point, we worked with several agencies to write a grant attempting to secure additional dollars in scholarships for future students.

3. HIT CURRICULUM

The curriculum for the bachelor's program was divided into two primary categories: prerequisite and foundational requirements; and the HIT common core. If the student came into the program with an associate degree in either health or technology, our hope is that many of the prerequisite and foundational requirements would be met. At a high level, courses required in the program fall into three general categories: liberal education courses, IT courses, and Nursing/Health related courses. Tables 1 and 2 illustrate that foundational requirements include courses in technology, zoology, medical terminology, and general education. The HIT common core consists of higher level courses in IT with several Technology and Nursing courses focused on Health Information Technology.

New Course Development

Many of the courses that we identified as important were already offered by our institution: Statistics, Health Care Informatics, Database Management, Ethics, as well as several other IT courses. However to offer a current and state-of-the-art program five new courses were developed:

- CIT 348 Information Management and Retrieval
- CIT 431 Health Information Technology I
- CIT 432 Health Information Technology II
- NSG 321 Healthcare Systems and Culture
- CIT 458 Collaborative System Design and Integration

Substantial amounts of effort went into the design and development of each of these courses. Almost all were developed in consultation with an industry professional. Additionally, CIT 431 and CIT 432 will be team-taught by an industry professional this fall.

Prerequisite and Foundation Requirements (65-69 credit hours):	**Credit Hours**
BTE 224 Medical Terminology	3
CIT 154 Personal Computer Concepts and Applications	3
CIT 157 Foundations of Information Technology I	3
CIT 158 Foundations of Information Technology II	3
CIT 214 Database Design and Development	3
CIT 268 Human Computer Interaction	3
CIT 276 Systems Analysis and Design	3
COM 135 Public Expression and Critical Rhetoric	3
CSE 163 Intro to Computer Concepts and Programming	3
MTH 102 Intermediate Algebra	3
ZOO 171 Human Anatomy And Physiology	4
ZOO 172 Human Anatomy And Physiology	4
ZOO 325 Pathophysiology or ZOO 342 Genetics or ZOO 232 Human Heredity	3-4
English Composition	6
Fine Arts and Humanities	3-6
Global Perspectives	9
Natural Sciences	6

Table 1. HIT Foundation Courses

Developing a Pre-HIT

We determined fairly early in the process that it would be beneficial to design a Pre-HIT designation. Majors are categorized as Pre-HIT majors or HIT majors depending on the course work completed to date. Pre-HIT majors become HIT majors when they had completed a specific set of courses in the major such as: Personal Computer Concepts and Applications, Intermediate Algebra with a C or better, Foundations of Information Technology I and II, and Human Anatomy and Physiology I and II. The designation as pre-HIT was implemented for two reasons. First, students need to complete courses in a particular order to be successful and determine if this major is appropriate for them. Secondly, the success of the program can better be measured when student outcomes are based on completion of these very basic requirements.

HIT Common Core (33 hours):	**Credit Hours**
CIT/CSE 262 Technology, Ethics and Global Society	3
CIT 348 Information Management and Retrieval	3
CIT 358 Information Technology Assurance and Security	3
CIT 431 Health Information Technology I	3
CIT 432 Health Information Technology II	3
CIT 448 Global and Strategic Issues in Information Technology	3
ENG 215 Technical Writing or ENG 313 Introduction to Technical Writing	3
ENT 316 Project Management	3
NSG 321 Healthcare Systems and Culture	3
NSG 343 Health Care Informatics	3
Business Statistics	4
Capstone Course: CIT 458 Collaborative System Design and Integration	3
Liberal Education Thematic Sequence	9
Additional coursework to meet bachelor's degree requirements of 128 earned credit hours	

Table 2. HIT Common Core

4. CHOOSING AN EHR APPLICATION

Because the Electronic Health Record is a fundamental component of our new degree program, choosing the right EHR was very important. We spent a significant amount of time researching, comparing and contrasting different EHRs. Our selection of an EHR was complicated by the sheer number of solutions available (over 300 at the time that we started our research), and the complexity of the systems themselves.

The Process of Selection

We identified the major stakeholders, including students, faculty, employers, and our IT support staff and identified factors that we felt would be important to each. Our budget for the purchase of both the hardware and the software to support the EHR solution was approximately $50,000 and would need to be spent before February 2013 (so ongoing support costs would have to be borne by the department). Many EHR implementations cost in the millions, so our budget was definitely a limiting factor in the selection process. Our research did uncover some web-based solutions that are free (supported by advertisement revenue), but they lacked the customizability that we thought was important to students who would be integrating solutions as a career. One of the key factors that we heard from our industry experts was that our graduates would need to be able to engage in workflow customization, or be able to match the solution they designed to the existing workflow of the client. We focused our efforts on those solutions that could support a wide variety of care settings, including hospital, ambulatory, and long-term care. Lastly, looking for a solution that included multiple modules (e-prescribing, document management, analytics, etc.) that students would be able to integrate together.

Selecting GE Centricity

We projected that the first class that would use the EHR solution would be taught in the fall of 2012, which meant that faculty would need to be trained in summer 2012. It was impossible, in the time frame given, to look at all of the available solutions. So, we contacted the top players by market penetration according to HIMSS (over 15,000 implementations was the benchmark) and researched the largest-scale open source projects. HIMSS has implementation numbers for the proprietary solutions, and it was easy to determine that the VA's VistA system is the largest open-source solution. Many of the larger vendors politely indicated that they had no solution that would fit our budget. As we fit the solutions to the matrix we eliminated all but the VistA solution and GE Healthcare's Centricity solution. We chose to implement GE Centricity in part because the Community College Consortia to Educate Health IT Professionals in Health Care Program (Community College Consortia, 2012) was using the VistA solution. Since our program is a bachelor's completion degree, some students entering our program might have received the training on VistA. Using a commercially available solution would provide those students with valuable experience.

EHR Infrastructure

All but the smallest EHR solutions require multiple servers to implement, and Centricity is no exception. To support the high-availability that we would need, our IT support group recommended two applications servers, a SQL cluster, and two terminal servers (to allow students and faculty to work from home), all virtualized and on a physical blade in our datacenter. Since this was being purchased through a DOL grant, the hardware would have to be separate from the existing infrastructure. The implementation team involved a project manager and IT support staff from the vendor, multiple IT support staff from the data center who are responsible for the configuration of the solution, IT support staff on the regional campus who will be responsible for managing the software after installation, and faculty from the department who will be using it.

5. IMPLEMENTATION

The program was approved at the state level in August of 2011, just days before the semester began. Therefore, it was not possible to begin the fall semester with the curriculum and students in place. Instead, the fall semester was used to educate internally, market the program, advise students, connect with additional professionals, and begin the process of purchasing and installing our EHR.

Educating the University

Internally, we worked to inform the various internal constituents regarding the new academic program. Time and attention needed to be given to developing new phone numbers, creating a "hitinfo" e-mail address, and creating e-mail lists of potential students. Before marketing to people outside of the university we had to make sure those within the university understood the program well enough to answer questions and direct inquiries. Because the program was offered on two different campuses, we needed to carefully and systematically educate both groups. We met with various groups within the institution including admissions, co-op/internships, advising, financial aid, and business services. In each of these sessions we explained the program, outlined the curriculum, indicated the type of students who may be especially interested, and we emphasized the likely interest in hiring these graduates.

Marketing the Program

With the help of the grant we had a very aggressive marketing campaign which included web, radio, newspaper, movie theaters, and billboards. We worked closely with a marketing team to identify the contents of advertisements, the visuals of the billboards and movie ads, and the newspaper advertisements. We developed, printed, and distributed flyers and booklets featuring the HIT program to potential students and other interested community members. All of the marketing pieces revolved around a similar look and message. Subsequent presentations were developed which kept this same marketing theme. The HIT program was featured in events with local high school counselors. We held an "HIT Open House" featuring a prominent local professional and spoke with many outside agencies.

Connecting With Health Organizations

In addition to marketing, the chair and several faculty members worked hard to network with additional working professionals in the field. The chair and faculty members went to local and national conferences, joined on-line HIT organizations, and met with local business and industry professionals in an attempt to both further educate themselves and to build awareness and interest in the program. The department spent several afternoons visiting and learning from several different local medical organizations. To date the department has connected with over 80 working professionals and plans to continue to stay connected with those professionals.

Advising

Our advertised "start date" for the program was January 2012. Prior to that time we individually talked with approximately 30 interested students about careers, course requirements and possibilities in HIT. By May of 2012 we have spoken individually to over 150 potential students. The program grew from an enrollment of zero declared majors in January 2012 to over 80 declared majors by May of 2012.

Not long ago our region had many high paying jobs in the paper, automotive, and steel industries that did not require a college degree. Those jobs have now been outsourced and our region's residents are painfully aware of the importance of a college education that connects to employment. Not surprisingly, almost all advisees were very focused on the employment outcome of their degree choice. Some students were incoming freshman who had researched the HIT industry and believed this was an advantageous place to start their career. Some students had been laid off their previous positions and had funding to pursue retraining. Veterans who had served as medics found the HIT program to be a good connection between their previous skills and future employment.

Students who had not been accepted into the highly selective nursing program at our institution found they could translate their coursework and interest into the HIT program. Second career nurses who no longer felt able to physically assist patients were attracted to this program as a way to leverage their valuable content knowledge without the level of physical exertion their previous responsibilities required.

Students found the HIT program attractive for a number of reasons such as: strong career focus, broad future prospects of information technology, additional coursework that could lead to promotion in a nursing career, the opportunity to use "real" EHR software (GE Centricity), and the convenient location and attractive tuition of the Miami University regional campuses. Some students expressed concern that once EHR implementations were complete that there would not be additional employment opportunities available to them. While there is a great deal of pressure to have implementations completed as soon as possible, it is our belief that important employment opportunities will continue to exist due to the changing nature of healthcare, reimbursement policies, reporting requirements, legislative changes, legacy issues, and security changes, to name a few.

6. SUCCESSES, CHALLENGES, AND CONCLUSIONS

In a relatively short period of time, the department moved from an abstract idea to the implementation of a new Bachelor of Science degree with over 80 students who have declared a major in Health Information Technology. In retrospect, there were many things done right in the development of the program the highlights of those are listed below:

- Involving HIT professionals from the beginning
- Including Nursing faculty in the development of the program
- Distributing the required work within the department
- A careful and systematic approach to the selection of an EHR
- A deliberate effort to educate within the university
- An aggressive and comprehensive marketing plan
- Expert and pro-active advising
- Monthly contact with students via e-mail educating them about course offerings and special events
- Developing a wide network of HIT professionals

A New Field

Perhaps our biggest challenge in the creation of this program revolved around the "newness" of this field. Established standards and benchmarks for success are not established. We did not have a published "body of literature" upon which we could draw. Jobs in this area are new and therefore, employers find the needs for such positions rapidly changing. Related to this challenge is that the faculty in our department have backgrounds in computer science and technology (not healthcare). While nursing played a major part in the development of the program, the health expertise within the department is limited.

Advising

Advising new students proved to be far more time intensive than expected. Because we designed this program as a bachelor's completion degree, many students came to the program with a significant number of credit hours already completed. These credit hours needed to be carefully and systematically evaluated. The HIT program requires the completion of a number of courses that are highly sequenced and as a result scheduling is advising intensive. For example, if a student does not take courses at the appropriate time, then there is a strong possibility that graduation could be delayed. Not only is this inconvenient, but many students have educational funding for a limited period of time.

Quarters to Semesters

Because we developed a program that is intended to articulate well with students who have associate degrees, we worked hard to establish some initial articulation agreements with local community colleges. The process was somewhat difficult because of the additional stress several of these institutions were under because of a transition from quarters to semesters. All public universities in the state of Ohio are converting from quarter systems to semester systems with the implementation date being fall of 2012. While we are on semesters, the community colleges we worked with were not. The community colleges were re-designing entire curriculums to the semester system making it difficult to identify which courses would in fact transfer. Additionally, current students bring in credits which are on the quarter system. As a result, some transfer coursework only represents a portion of the material needed to complete HIT requirements. We have used a petition process within the department to determine which combinations of courses from other institutions can be combined to meet our requirements. This work is highly customized as each student brings in their own combination of coursework from various institutions. If petitions are approved, notations are made on the student record to show progress towards degree completion.

Students who have brought in a large number of credits often have busy lives involving child/parent care and busy work schedules. As a result, students have become more interested in online and hybrid offerings. This has caused us to look at our portfolio of course offerings to determine which courses may be suited for online or hybrid delivery.

Transition of Leadership

An additional challenge included the transition of leadership in the department. In the three years between the development of the idea and the implementation of the program, the department had three chairs. While each chair remained involved in the process (which greatly facilitated continuity) the change in leadership created an additional layer of complexity to the process.

In conclusion, developing a new Bachelor's degree program has been an exciting, interesting and challenging effort. In a very short period of time, this department has moved from an abstract idea to having 80 majors. While the curriculum has been developed, the program approved, and we have a significant cohort of new students, our work in this area has really just begun.

7. REFERENCES

Bureau of Labor Statistics, U.S. Department of Labor, *2012–2013 Occupational Outlook Handbook*, Retrieved on 04-30-2012. http://www.bls.gov/ooh/.

Community College Consortia to Educate Health IT Professionals in Health Care Program (2012). Retrieved 06-12-2012 from http://www.healthit.hhs.gov/portal/server.pt?open=512&objID=1804&mode=2

Gonsalves, A. "Health IT Jobs Outlook Bright," *Information Week*, February 12, 2010

Health IT No. 1 List Top 10 Careers. (2011, May 20). Retrieved 04-24-2012 from http://www.healthcareitnews.com/news/health-it-no-1-list-top-10-hot-careers.

HHS Secretary Kathleen Sebelius announces major progress in doctors, hospital use of health information technology (2012, February 17). Retrieved 04-30-2012 from http://www.hhs.gov/news/press/2012pres/02/20120217a.html.

HITECH Programs (2011). Retrieved 04-24-2012 from http://healthit.hhs.gov/portal/server.pt/community/healthit_hhs_gov__hitech_programs/1487.

Network and Computer Systems Administrators, Bureau of Labor Statistics, U.S. Department of Labor (2012), *2012–2013 Occupational Outlook Handbook*. Retrieved 04-30-2012 from http://www.bls.gov/ooh/Computer-and-Information-Technology/Network-and-computer-systems-administrators.htm#tab-6.

Overview 0f 2010-2020 Projections, Bureau of Labor Statistics (2012), U.S. Department of Labor, *2012–2013 Occupational Outlook Handbook*, Retrieved 04-30-2012 from http://www.bls.gov/ooh/About/Projections-Overview.htm.

Shaffer, Vi. (2011). Hype Cycle for Healthcare Provider Applications and Systems. Retrieved 05-04-2012 from www.gartner.com.

Software Developers, Bureau of Labor Statistics, U.S. Department of Labor (2012), *2012–2013 Occupational Outlook Handbook*. Retrieved 04-30-2012 from http://www.bls.gov/ooh/computer-and-information-technology/software-developers.htm#tab-6.

Editor's Note:

This paper was selected for inclusion in the journal as the ISECON 2012 Best Paper The acceptance rate is typically 2% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2012.

Engaging Community Service Students through Digital Portfolios

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Abstract

Community engagement courses are becoming common in the discipline of information systems. In this paper the author analyzes the benefits and the challenges of an e-Portfolio in a course engaging students with a community of individuals with developmental and intellectual disabilities. The case study in the paper finds generally higher engagement of students from the community projects of the course if an e-Portfolio is designed flexibly for the students. The findings further indicate generally higher impact of the service and systems on the individuals with disabilities and also on the students. This paper can be beneficial to instructors considering e-Portfolio as a method for improving the impact of service involving systems.

Keywords: community engagement, digital portfolio, e-Portfolio, information systems curriculum, service-learning

1. BACKGROUND OF PAPER

Community engagement or service-learning is defined as an "… approach in learning … that integrates community service with academic [courses] to enrich learning [and] teach civic responsibility …, engag[ing] students in addressing unmet issues or needs in a community …"(Pritchard & Whitehead, 2004). Critical to service-learning are mutuality (Rhoads, 1997) and reciprocity (Kendall, 1990), as community and students benefit from the courses as equivalent learners. The design of the learning is in a project or service for the community that enhances the experiences of students in issues of the community and in lessons of civic responsibility (Lawler & Li, 2005). The experiences frequently recorded in reflections on the service are important in the learning of students. This learning may be augmented by educational technology (Everett, 2010).

Digital portfolio or e-Portfolio is defined as a "digitized collection of artifacts [of] … accomplishments, demonstrations [blogs and journals, multimedia, presentations, podcasts and project samples] and resources that record reflections [from courses]" (Lorenzo & Ittelson, 2005 para. 1) of students. e-Portfolio is a complement to learning management systems as the Blackboard Learning system in community-encouraging reflections of students. e-Portfolio is an easy facility for net generation students familiar with recording reflections on Facebook and YouTube social software systems (Clark, 2009). They may mash up multiple media in recording reflections on e-Portfolio. Features of e-Portfolio in enabling self-publishing reflections of students enrich if not innovate learning and teaching (Clark, 2009). Pedagogy is further focused on the students as they formulate knowledge in a social manner through e-Portfolio (Heafner & Friedman, 2008). e-Portfolio fosters improved meta-cognitive skills (Clark, 2009). Finally, e-Portfolio is a full-fledged Web 2.0 platform (O'Reilly, 2005) on which reflections are shared with instructors and other students.

The benefits of an e-Portfolio, and of educational platforms of technology (Hyman, 2012), are evident in the literature (McGee & Diaz, 2007). The platform is furnished to help instructors and net generation students. It is in 50% of higher education institutions in the United States (Green, 2008). Though e-Portfolio can benefit community engagement or service-learning courses, challenges of expected higher engagement of students on projects of the courses and higher impact of the services on the community organizations and students are not evident in the literature. The customization of an e-Portfolio by instructors (Purcell & Perritt, 2008) is important in enabling the benefits to instructors, organizations and students. The effective impact of an e-Portfolio and other platforms of systems (Hartman, Dziuban, & Brophy-Ellison, 2007) and of generic technology, is a central issue in 21st century learning (Bolick, Berson, Coutts, & Heinecke, 2003) and is analyzed in this case study.

2. INTRODUCTION TO CASE STUDY

Course: Community Empowerment through Information Systems and Technologies

Project: Personal-Centered Planning with Individuals with Developmental and Intellectual Disabilities through Presentation Technology

Platform: e-Portfolio System

The author analyzes the benefits and the challenges of an e-Portfolio in a Community Empowerment through Information Systems and Technologies course, in which he is the instructor, at the Seidenberg School of Computer Science and Information Systems at Pace University.

The course concentrates on empowering individuals with developmental and intellectual disabilities (i.e. autism, cerebral palsy, down syndrome, motor-neuron and tourett syndrome) at AHRC New York City, a community organization partner of the school, by engaging students of the university in formulating person-centered plans (Mount & Zwernik, 1988) enabled by presentation technology, the course project. The goals are engaging the students in helping the individuals with disabilities to be presentable in society through technology tools and in having the students reflect on the partnered relationships through the service by posting their reflections on an e-Portfolio system. The outcome of the course is essentially in the impact of increased civic responsibility learned through partnership if not problem-solution (Fenwick, 2001) with a neglected population of society – an outcome of service more meaningful than solutions of technology (Pernu, 2011). This course fulfills an area of knowledge (AOK) in civic responsibility in society of the core curriculum of the university and is required of all students, including non-systems students.

The course comprised 95 students, 47 in fall semester 2011 and 48 in spring semester 2012, and an equivalent number of individuals with disabilities at AHRC New York City. The students aged 18-20 (66%), 21-22 (19%), 23-24 (12%) and 25+ (3%) and consisted of female (49%) and male (51%) students. The students consisted of a diversity of freshman (29%), sophomore (27%), junior (27%) and senior (17%) students, and 98% were not in computer science or information systems degree programs of the school but were experienced in social software technology as net generation students (Wilen-Daugenti, 2009), though 97% were not knowledgeable in the e-Portfolio system of the university. The students (81%) were generally not experienced with people with developmental and intellectual disabilities or other disabilities, and 74% were generally not exposed to neighborhood or school service. The impression of the instructor was that most of the students were not initially interested or motivated in service-learning, as they chose the core course of the curriculum because of convenience of load scheduling. The demographic distribution of the students is displayed in Table 1 of the Appendix.

The projects of the course consisted of each student deliberatively engaging her / his individual with developmental and intellectual disabilities at the facilities of AHRC New York City. The focus of the projects was the formulation of "brag nuggets" (Klaus, 2012), hopes and interests of the individuals, into person-centered plans (Holburn, Gordon, & Vietze, 2007) by the students. The person-centered plans were enabled by presentation as digital stories through special i-pad, i-phone, smart board, speech and tablet technology tools that helped the individuals to be presentable and productive in society. The individuals and the students were engaging in partnership on the plans and tools 3 hours 1 day each week for 14 semester weeks, with presentations of the projects to organizational personnel on the 14th week. Following each engagement at the end of the day, and at the ends of the mid-term and final semesters, the students were required to furnish blogs and journals to the instructor reflecting on the progress of the projects and related research stories (Brightman, 2008), reflections recorded in an e-Portfolio of the course.

The e-Portfolio of the course was customized as a full e-Portfolio (Villano, 2006) by the instructor and was initiated in the curriculum in partnership with the Center for Teaching, Learning and Technology (CTLT) of the university. The e-Portfolio was an exceptionally flexible MAHARA open source system. The e-Portfolio was infused with a regimen of sections for engagement of the students in the experience of the projects (Swan & Hicks, 2007) through Web 2.0 technology (Shelly & Frydenberg, 2011):

- My Biography: What I Am Bringing to AHRC New York City;
- My Facebook Home Page;
- My Biography in Graphic Representation;
- My Friends in the Course at Pace University;
- My Friends and Partner at AHRC New York City;
- My Personal Journey in Service (Blogs of Semester);
- My Project at AHRC New York City (Project Samples);
- My Mid-Term Reflection Journal on Disability Land Book and Project;
- My Final Reflection Journal on Impacts of Semester; and
- My Semester of Service at AHRC New York City.

To encourage engagement, information in the sections was permitted by the instructor and the students to be sharable with other students in the semesters. The e-Portfolio was a learning system joined to the Blackboard Learning system, and the Digital Commons: Community Action Forum in the Seidenberg School Library system, of the university. The design of the e-Portfolio of the course is displayed in Table 2, and the dimensions of the e-Portfolio as a learning management system are displayed in Figure 1 of the Appendix.

In this study the author analyzes the customization of the e-Portfolio features in enabling or not enabling higher engagement of and higher impact on the students at the Seidenberg School, and in enabling or not enabling higher impact on the individuals with developmental and intellectual disabilities at AHRC New York City. Is the design of the e-Portfolio facilitating higher experience of and impact of the service on the students at the school? Is the design of the e-Portfolio facilitating higher impact of the service on the individuals with disabilities at the organization? Is the design of the e-Portfolio facilitating the dual goals of higher experience of the students and higher impact of the services at a higher learning level of civic responsibility? This study can attempt to answer these questions by analyzing the experiences from and the impacts of the projects in the course, as reflected upon by the students and the community organization staff. Few analyses (Bulger, Mayer, & Almeroth, 2006, Stoecker, 2005, & Strand, Marullo, Cutforth, Stoecker, & Donohue, 2003) evaluate the benefits of the impact of service-learning (Speck, 2001), and few evaluate the benefits and challenges of an e-Portfolio service-learning system, the focus of this study.

3. FOCUS OF CASE STUDY

This paper evaluates the benefits and challenges of the e-Portfolio in the Community Empowerment through Information Systems and Technologies course of the author. The author explores the features of the e-Portfolio in furnishing or not furnishing increased engagement of the students at the Seidenberg School and in furnishing or not furnishing increased impact on the individuals with disabilities at the community organization and on the students. The author highlights the importance of an e-Portfolio and social media (Wakefield, 2012) in the increased learning of net generation students in a new social setting (Moore, Fowler, & Watson, 2007). The importance of an e-Portfolio in the learning of students may not be clear to instructors in schools (Guidry & Lorenz, 2010). This paper can be beneficial to instructors considering initiating a social space system.

4. METHODOLOGY OF CASE STUDY

The methodology of this paper focused on the projects of the Community Empowerment through Information Systems and Technologies course in the fall 2011 and spring 2012 semesters at the Seidenberg School of Computer Science and Information Systems of Pace University. There were pre-course demographic 7-item (synopsized in Table 1) and project 27-item questionnaires of each of the 95 students; 16 detailed blog and journal e-Portfolio postings of each of the students; 21 e-Portfolio postings of multimodal project samples and simulations of the technology tools of each of the students; 3 mid-term and final reflection e-Portfolio postings and other postings of each of the students (synopsized in Table 2); and post-course semi-structured focus groups of a sample of 11 of the students and 9 of the community organization staff. This data was read by the author-instructor, as to the on-going experiences of and the impacts on the students and the staff already recorded on the e-Portfolio system, and was summarized by him at the end of each semester. This information furnished overall perceptions from the recordings of the 95 students and of the 9 staff on the project services that were consolidated and evaluated by the author. The investigation was performed by the author-instructor in the period of the semesters of September 2011 – May 2012 in methodology prescribed by Yin (2003). This phase of the investigation was a descriptive exploratory study.

5. CASE STUDY OF e-PORTFOLIO SYSTEM

The author analyzed the benefits and challenges of the e-Portfolio in the Community Empowerment through Information Systems and Technologies course at the Seidenberg School.

Benefits of e-Portfolio System

The e-Portfolio in the Community Empowerment through Information Systems and Technologies course allowed the benefit of creativity in content design. Each of the students customized the content of the e-Portfolio in a diversity of media, as multimedia on the community projects could be easily inserted on to the e-Portfolios (i.e. My Project at AHRC New York City: View My Project, View My Video and View My Technology Tools), in contrast to the relative cumbersomeness of the Blackboard Learning system. Though the instructor defined the feature hierarchy of the e-Portfolio, as displayed in Table 2, each of the students determined the look of the e-Portfolio sections. Most of the students (74/95 or 77% [found from the data]) enhanced the e-Portfolio in an expressive manner, as they posted much multimedia and reflected and reported projects of service (My Personal Journey in Service, My Mid-Term Reflection Journal on Project and My Final Reflection Journal on Impacts of Semester), though most of them (92/95 or 97%) had no experience with e-Portfolios. The flexibility of the system was a change of pace for the students that contributed in general to evident freedom and higher engagement of the students (87/95 or 91%), in the explored perceptions of the students.

The e-Portfolio allowed the benefit of considerable creativity in device display. Each of the students displayed feature images of the technology (i.e. i-pad, i-phone, smart board, speech tools and tablet tools) of the projects on which they partnered with the individuals with developmental and intellectual disabilities (i.e. View My Project, View My Video and View My Technology Tools). Each of the students and the staff explained how they helped the individuals with disabilities in learning the technology (i.e. My Personal Journey in Service). Most of the students (91/95 or 95%) and all of the staff (9/9 or 100%) explained how the mentoring of the individuals on the technology and the power of the tools had a generally high impact on the perceived pride of the individuals (i.e. My Final Reflection Journal on Impacts of Semester), though most of the students (77/95 or 81%) had no experience with individuals with disabilities. The functionality of the system in furnishing prominent reflection on project results of the tool and on the sociality of the individuals and the students contributed to generally higher engagement of the students (77/95 or 81%), higher impact on the individuals with disabilities (91/95 or 95%), and higher impact on the students (81/95 or 85%), in the perceptions of the students and the community organizational staff representing the individuals.

The e-Portfolio contributed to disciplined engagement of the students not easily enabled in discussion board flows on the Blackboard Learning system. Following each engagement at the facilities of the AHRC New York City organization, each of the students explained personal progress or non-progress of the projects in formulated sections (i.e. My Personal

Journey on Service: Blogs). They explored the relationships and the service in mid-semester (i.e. My Mid-Term Reflection Journal on Project) and final semester (i.e. My Final Reflection Journal on Impacts of Semester). From initial uncertainty in the plan for service to certainty in the meaning of service, most of them (66/95 or 69%) evolved in improved perception skills of the service, though most of them (70/95 or 74%) had no experience with service or volunteering. The perceptions formed a perspective of a progressive service trail. The functionality of the system facilitated generally higher experience of the students (72/95 or 75%), as they reflected ritualistically on progression in civic responsibility and service.

The e-Portfolio in the course enabled engagement of initial laggard students (23), defined as those who delayed interactions with the individuals or delayed postings on the projects due to a lack of proper self-motivation. The in-depth display of projects and tools (i.e. My Project at AHRC New York City) and the recording of reflections (i.e. My Personal Journey on Service) of interested students motivated most (18/23 or 78%) of the non-interested students to be engaged more seriously in reflecting on service (i.e. My Biography: What I Am Bringing to AHRC New York City, My Friends in the Course at Pace University and My Friends and Partner at AHRC New York City). Inasmuch as the e-Portfolios were privy and public to all of the service-learning students, most (21/23 or 91%) of the non-interested students were motivated to be professional in service showcasing (i.e. My Semester of Service at AHRC New York City). The inclusion of the non-interested students enabled further involvement of a mass of service-learning students (33/95 or 34%) in initiating a Disability Pride Day proposal at the university. The openness of the e-Portfolio as a social space system facilitated generally higher experience of more students in service (67/95 or 70%), in the perceptions of the students.

Finally, the e-Portfolio facilitated the engagement of interested students in new programs of service. The instructor found frequent recording of other neighborhood service of students (i.e. My Other Service During or Since Semester – What I Have Been Doing in Service). These students (15/95 or 15%) joined the instructor in extra-curricular initiatives of mentoring programs of high school students and other teenagers with developmental and intellectual disabilities at the AHRC New York City Middle / High School. They recorded the services and the reflections on the services on the system, as the system may be updated by them throughout their university years, unlike the Blackboard Learning system. The perpetuity of e-Portfolio is furnishing a foundation for higher involvement of more students in service.

Challenges of e-Portfolio System

The e-Portfolio is a challenge for an instructor. The instructor has to define the feature hierarchy of the e-Portfolio in the context of a social space system, as displayed in Table 2, in addition to defining a normal syllabus. The instructor may also have to enable a link to the Blackboard Learning system and the Digital Commons Library system, as displayed in Figure 1, inasmuch as the systems may not be linked as one seamless system. The Center for Teaching, Learning and Technology may be helpful to instructors in learning the functionality of an e-Portfolio system and the nuances of social space systems and in managing the e-Portfolio MAHARA technology. Inevitably instructors in e-Portfolio need to be the initiators of the e-Portfolio.

The e-Portfolio, as founded on MAHARA open source technology, is a challenge for an instructor. Though open source technology is a benefit for design flexibility ideal for instructors and for formatting ideal for students, the feature hierarchy of instructors may not be enabled as a fixed guideline for students like in the Blackboard Learning system. Students may format and furnish information in diverse locations on the e-Portfolio system. To not dampen the enthusiasm of students, instructors may have to be flexible in formatting hierarchal guidelines in non-hierarchal settings. The instructor in e-Portfolio needs to be knowledgeable of the protocol of social space systems.

The exploratory findings of enabling generally higher engagement of students and higher impact on students from service are benefits but may be a challenge of the course. Higher number of female students (49%) that may be considered more acclimated to caring may favor higher perceptions of service without e-Portfolio impact. Higher numbers of liberal arts and sciences (39%), education (4%) and health professions (1%) students (44%) that may be more acclimated to service may even favor higher perceptions of service without the e-Portfolio impact. Most of the students joining the initiatives of the instructor in the ad hoc mentoring programs at the AHRC New York City community organization are female liberal arts and sciences students. The instructor in the Seidenberg School needs to pursue further empirical findings isolating favoritism likelihood, so that the benefits from the e-Portfolio system may be clearer for future instructors.

The e-Portfolio is a challenge for an instructor in projects of service. Projects engaging individuals with developmental and intellectual disabilities and other disabilities have to conform to non-disclosure regulations in the semesters of service. Students may not furnish the identity of partners on to the e-Portfolio. They may not insert videos on to the e-Portfolio nor on to private systems (e.g. YouTube) in order to upload the videos on to the e-Portfolio system. The instructor in e-Portfolio needs to recognize regulations on service, review the regulation requirements with the students, and review the postings for violations.

The instructor is challenged by increased management of an e-Portfolio. Inasmuch as blogging and journaling are diverse and frequent, and may be fragmented or floundering for resolution on an e-Portfolio social space, instructors have to ensure that they are responding sooner to students and to tensions than on non-social space systems, such as the Blackboard Learning system. They have to ensure that more motivated in service students are often sharing practices of service with less motivated in service students through presentation of professional e-Portfolios. They have to review the e-Portfolios of students through rubrics that measure the service-learning of the students, which may be more qualitative than quantitative in measurement. Lastly, in attempting to ease the burden of follow-up on the projects, the instructor in e-Portfolio in service-learning needs to be a mentor not a sage to the students as she and the students interact in social space systems.

Summary of e-Portfolio System

The exploratory findings from the case study in the denote the benefits of the e- Portfolio on engagement in learning civic responsibility. The design of the e-Portfolio encouraged a generally higher level of service (Weigel, 2002), as the students reflected on the service in the social space of the system. Literature (Dietering, 2005) highlights the importance of the social space of systems. The importance of the impact of the resultant service on the individuals with developmental and intellectual disabilities at the community organization is indicated in the study. The findings are further indicating the challenges of the e-Portfolio and the furnishing of help by a center for teaching, learning and technology of a university. The exploratory study highlights lastly the potential of a social space system on which students felt proud to be stakeholders (Wortham, 2012).

6. IMPLICATIONS OF CASE STUDY

The criticality of a center for teaching, learning and technology in e-Portfolio leadership is an implication of the study. The Center for Teaching, Learning and Technology (CTLT) at Pace University enabled the instructor in the initiation of the e-Portfolio in the fall 2011 and spring 2012 semesters. Literature (Xuesong, Olfman, & Ractham, 2007) indicates the importance of a centralized organization for teaching, learning and technology in furnishing learning platform systems. The case study indicated the potential of integrating the Blackboard Learning and Digital Commons Library systems at the university. The future of e-Portfolio systems is dependent on centers for technology, learning and technology attuned to innovation in learning technology.

The creative design of an e-Portfolio in enabling generally higher engagement of net generation students is another implication of the study. The course customization of the e-Portfolio enabled generally higher engagement of project service of the students. The customization enabled the instructor in the initiation of service-learning on a social space system enjoyed by the students. Flexibility and freedom of instructors are important in the initiation of such systems. The future of e-Portfolio systems is dependent on instructors attuned to social space themes.

The effort in formulation of an e-Portfolio service-learning program by an instructor is an implication of the study. The emotional investment in a service-learning program is indicated in the literature (Langseth, 2000), but further instructor investment in an e-Portfolio service-learning program is indicated in the study. The instructor involvement in the methodology of a social space system, leading to its quality and usefulness and to subsequent instructor satisfaction (Najmul Islam, 2012), is indicated in this study. The instructor sensitivity to the protocol of such systems is also indicated in this study. The impact of this sensitivity is evident in the generally higher engagement and generally higher impact of service of the net generation students.

The expressiveness of the net generation students to digital e-Portfolios is a further implication of this study. The display of project samples of the service and the systems was enabled by the fluid functionality of multimodal presentation. Literature (Clark, 2009) indicates the importance of the medium in the reactions of students. Literature (Pemu, 2011) indicates the learning potential when students respond to the results of the service and the system tools that impact others. The impact of the e-Portfolio setting is in the potential of proactive students advocating for social justice (Marullo, 1999).

The final implication of this study is in the perpetuity of the e-Portfolio system. The pride of the students in the results of service was evident in the polished professionalism of the e-Portfolios, of which the highest in professionalism (10/95 or 10%) was shared in the Digital Commons Library system of the university. The e-Portfolios may be maintained by the students, as the Center for Teaching, Learning and Technology stores the portfolios on the mechanism of an open source system for them. The students may post progress on other services as they pursue studies at the university. The impact of the system is in a student success story.

7. LIMITATIONS OF PAPER AND OPPORTUNITIES IN RESEARCH

The paper is not a confirmatory but an exploratory study of the benefits and the challenges of an e-Portfolio in one course at a non-profit organization. The findings of a case study with a frequently small sample may not be generalized without caution (Guthrie & Navarrete, 2003). However, the paper illuminates e-Portfolio practices that may benefit instructors in service-learning interested in a new social space system. Such practices may be customized further by instructors in service-learning. The author expects a larger sample of students in the fall 2012 semester, from which he will interpret anew the practices at the Seidenberg School, in order to publish an empirical study in 2013.

8. CONCLUSION OF PAPER

The paper highlights the benefits of an e-Portfolio in higher engagement of learning and in higher impact of service in the period of the study. The design of the e-Portfolio in the study encouraged a higher level of service of the students and a higher level of impact on both the individuals with developmental and intellectual disabilities and on the students. The paper highlighted the expanded expressiveness of the net generation students to e-Portfolios as an important implication of the study. However, the paper indicated flexibility in the functionality of an e-Portfolio as important in the interactions of net generation students on projects of service involving systems. Moreover, the paper indicated the effort and the emotional investment of the instructor as especially important in the formulation of an e-Portfolio service-learning program. The potential of an e-Portfolio in increased learning of students was further noted in the study. This paper may be beneficial to instructors initiating an e-Portfolio system as a method for integrating a social space system into their service-learning teaching. Research of social space systems will be further pursued in 2013.

ACKNOWLEDGEMENTS

The author acknowledges from the Center for Teaching, Learning and Technology (CTLT) of Pace University a grant stipend of $800 for membership on a committee advocating for the e-Portfolio system with the faculty of the university.

9. REFERENCES

Bolick, C., Berson, M., Coutts, C., & Heinecke, W. (2003). Technology applications in social studies teacher education: A survey of social studies methods faculty. Contemporary Issues in Technology and Teacher Education, 3(3), 300-309.

Brightman, A. (2008). DisabilityLand. SelectBooks, Inc., New York, New York.

Bulger, M., Mayer, R.E., & Almeroth, K.C. (2006). Engaged by design: Using simulations to promote active learning. Proceedings of the World Conference on Educational Multimedia, Hypermedia and Telecommunications, Chesapeake, Virginia.

Clark, J.E. (2009). E-portfolios at 2.0: Surveying the field. Association of American Colleges and Universities Peer Review, 11(1), 1,4.

Dietering, A.M. (2005). Learner-centered learning and blogging. Edutech, February.

Everett, D.R. (2010). Service-learning in distance education: E-mentoring project connect. Proceedings of the Information Systems Educators Conference (ISECON), Nashville, Tennessee, 27(1329), 2.

Fenwick, T. (2001). Experiential Learning: A Theoretical Critique for Five Perspectives. Eric Clearinghouse on Adult, Career, and Vocational Education, Ohio State University, Columbus, Ohio.

Green, K. (2008). Campus computing 2008: The 19th national survey of computing and information technology in american higher education. Campus Computing Project.

Guidry, K., & Lorenz, A. (2010). A comparison of student and faculty academic technology use across disciplines. Educause Quarterly, 33(3), March.

Guthrie, R., & Navarrete, C. (2003). Service-learning impact on information systems (is) students in a web development course. Proceedings of the Information Systems Educators Conference (ISECON), San Diego, California, November, 2(8).

Hartman, J.L., Dziuban, C., & Brophy-Ellison, J. (2007). Faculty 2.0. Educause Review, 42(5), 62-76.

Heafner, T., & Friedman, A. (2008). Wikis and constructivism in secondary social studies: Fostering a deeper understanding. Computers in the Schools, 25(3,4), 288-302.

Holburn, S., Gordon, A., & Vietze, P.M. (2007). Person-Centered Planning Made Easy: The Picture Method. Paul H. Brookes Publishing Company, Baltimore, Maryland.

Hyman, P. (2012). Stanford schooling – Gratis!: Stanford University's experiment with on-line classes could help transform computer science students. Communications of the ACM, 55(3), 22.

Kendall, J. (1990). Combining Service and Learning: A Resource Book for Community and Public Service. National Society for Internships and Experiential Education, Raleigh, North Carolina, 22.

Klaus, P. (2012). A chance to see disabilities as assets. The New York Times, Jobs, February 5.

Langseth, M. (2000). Maximizing impact, minimizing harm: Why service-learning must more fully integrate multicultural education. In C. O'Grady (Ed.), Integrating Service-Learning and Multicultural Education in Colleges and Universities. Mahwah, New Jersey: Lawrence Erlbaum Associates, 250.

Lawler, J., & Li, Z. (2005). Student engagement in a flexible model of service learning in information systems curricula. Journal of Informatics Education Research, 7(2), 53-90.

Lorenzo, G., & Ittelson, J. (2005). An overview of e-portfolios, in Oblinger, D. (ed.) Educause Learning Initiative, July. Boulder, Colorado.

Marullo, S. (1999). Sociology's essential role: Promoting critical analysis in service-learning. In J. Ostrow, G. Hesser, & S. Enos (Eds.), Cultivating the Sociological Imagination: Concepts and Models for Service-Learning in Sociology, Washington, D.C.: American Association of Higher Education.

McGee, P., & Diaz, V. (2007). Wikis and podcasts and blogs! Oh, my! What is a faculty member to do? Educause Review, 42(5), 28-40.

Moore, A.H., Fowler, S.B., & Watson, C.E. (2007). Active learning and technology: Designing change for faculty, students, and institutions. Educause Review, 42(5), 42-61.

Mount, B., & Zwernik, K. (1988). It Is Never Too Early, It Is Never Too Late: A Booklet about Personal Futures Planning. Governor's Council on Developmental Disabilities, Minnesota.

Najmul Islam, A.K.M. (2012). The determinants of the post-adoption satisfaction of educators with an e-learning system. Journal of Information Systems Education, 22(4), 319-331.

O'Reilly, T. (2005). What is web 2.0?: Design patterns and business models for the next generation of software. O'Reilly Media, September 30.

Pemu, C. (2011). Service-learning and social justice. National Youth Leadership Council (NYLC), December 12, 6.

Pernu, C. (2011). Conducting meaningful service is key to service-learning benefits. National Youth Leadership Council (NYLC), 29(2), 1,4.

Pritchard, F.F., & Whitehead, G.I. (2004). Serve and Learn: Implementing and Evaluating Service-Learning in Middle and High Schools. Lawrence Erlbaum Associates, Mahwah, New Jersey.

Purcell, S., & Perritt, D. (2008). Understanding and promoting best practices in technology implementation in higher education classrooms. In K. McFerrin (Ed.), Proceedings of the Society for Information Technology and Teacher Education International Conference 2008, Chesapeake, Virginia, 2194-2197.

Rhoads, R.A. (1997). Community Service and Higher Learning: Explorations of the Caring Self. State University of New York Press, Albany, New York, 150.

Shelly, G.B., & Frydenberg, M. (2011). Web 2.0: Concepts and Applications. Course Technology, Boston, Massachusetts, 9.

Speck, B.W. (2001). Why service learning? New Directions for Higher Education, 114, 3-13.

Stoecker, K. (2005). Research Methods for Community Change, Sage Publications, Inc., Thousand Oaks, California.

Strand, K., Marullo, S., Cutforth, N., Stoecker, R., & Donohue, P. (2003). Community-Based Research and Higher Education: Principles and Practices. Jossey-Bass, San Francisco, California, 1-15,81-85,123-135.

Swan, K., & Hicks, D. (2007). Through the democratic lens: The role of purpose in leveraging technology to support historical thinking in the social studies classroom. The International Journal of Social Studies Education, 21(2), 142-168.

Villano, M. (2006). Electronic student assessment: The power of the portfolio. Campus Technology, August 29.

Wakefield, K. (2012). Should professors use facebook to communicate with students? Faculty Focus, February 27, 1-2.

Weigel, V. (2002). From course management to curricular capabilities. Educause Review, January / February.

Wilen-Daugenti, T. (2009). .edu: Technology and Learning Environments in Higher Education. Peter Lang Publishing, Inc., New York, New York, 3.

Wortham, J. (2012). It is not about you, facebook. It is about us. The New York Times, Bright Ideas: Bits, February 11.

Xuesong, S., Olfman, L., & Ractham, P. (2007). Designing e-portfolio 2.0: Integrating and coordinating web 2.0 services with e-portfolio systems for enhancing users' learning. Journal of Information Systems Education, 18(2), 203-215.

Yin, R.K. (2003). Applications of Case Study Research, Second Edition. Sage Publications, Inc., Thousand Oaks, California.

APPENDIX

Table 1: Demographics of Community Engagement Students

	Fall Semester 2011	Spring Semester 2012	Total	
Demographics	**Frequency**	**Frequency**	**Frequency**	**Percentage**
Age				
18 – 20	34	29	**63**	**66%**
21 – 22	8	10	**18**	**19%**
23 – 24	4	7	**11**	**12%**
25+	1	2	**3**	**3%**
Gender				
Female	26	21	**47**	**49%**
Male	21	27	**48**	**51%**
Year				
Freshman	19	8	**27**	**29%**
Sophomore	11	15	**26**	**27%**
Junior	10	16	**26**	**27%**
Senior	7	9	**16**	**17%**
Degree				
Computer Science/Information Systems	0	2	**2**	**2%**
Non-Information Systems:				
Arts and Sciences	21	16	**37**	**39%**
Business	19	23	**42**	**45%**
Education	3	1	**4**	**4%**
Health Professions	1	0	**1**	**1%**
Not Decided	3	6	**9**	**9%**
Experience in e-Portfolio				
Yes	2	1	**3**	**3%**
No	45	47	**92**	**97%**
Experience with Individuals with Disabilities				
Yes	7	11	**18**	**19%**
No	40	37	**77**	**81%**
Experience with Service and Volunteering				
Yes	14	11	**25**	**26%**
No	33	37	**70**	**74%**
Total	**47**	**48**	**95 Students**	**100%**

Table 2: Design of e-Portfolio System in Community Engagement Course

"Name"

Please post your name.

My Biography: What I Am Bringing to AHRC New York City

In this section please post a highly informative half-page to full page Biography of yourself.

Please post information on any community service performed by you in high school, in the neighborhood, and / or in university.

If you have or have not performed any service, please provide information on what interests or skills you might provide to AHRC New York City.

Please post a color photograph of yourself.

My Facebook Home Page (Optional)

In this section please optionally post your Facebook home page.

My Biography in Graphic Representation (Optional)

In this section please optionally post your posted Biography in Wordle.

My Friends in the Course at Pace University

In this section please post a couple of color photographs of your colleague students in this course.

My Friends and Partner at AHRC New York City

In this section please post a few photographs of your partner at AHRC New York City with you, with colleague students and you in the course, and with you and a couple of the staff at AHRC New York City.

(You may photograph at locations of Pace and / or at locations in the neighborhood on tours.)

My Personal Journey in Service

In the sub-sections of this section, please post a detailed and informative half-page to full-page story of your class days with your partner at AHRC New York City, focusing on your impressions of your interactions with your partner, including any issues, and on your impressions on the progress of your project with your partner.

You may even post photographs of Pace and neighborhood tours.

Blog postings are due by the end of class day mid-night, otherwise you will be penalized in your Final Grades.

(I will be reading and responding to your blog postings by the next day of your postings in the "Feedback" section of your e-Portfolio system.)

Blog of 1/24/12
Blog of 1/31/12
Blog of 2/7/12
Blog of 2/14/12
Blog of 2/21/12
Blog of 2/28/12
Blog of 3/6/12
Blog of 3/20/12
Blog of 3/27/12
Blog of 4/3/12
Blog of 4/10/12
Blog of 4/17/12
Blog of 4/24/12
Blog of 5/1/12

My Project at AHRC New York City (Project Samples)

In this section please post presentation samples of your project, focusing on project specifics.

This section is essentially highlighting your project progress and your role with your partner.

You may be as creative and imaginative as you like in this section.

View My Project

In this sub-section please post the college bound and / or job bound person-centered plans of the project for your partner at AHRC New York City.

- View My Technology Tools (Optional)

In this sub-section please post color photographs of any special technology tools that you are employing with your partner at AHRC New York City, and please post references to the URLs of the technology vendors.

- View My Video

In this sub-section please post a 1 - 3 minute video of you and your partner or you and your partner with colleague students of Pace and / or with staff of AHRC New York City.

You might prepare the video through the Pace and neighborhood tours.

My Mid-Term Reflection Journal on [Book] DisabilityLand and Project

In this section please post a full 3 page Journal, reflecting on your personal progress with your partner at AHRC New York City, referencing [Book] DisabilityLand.

Journal should be an in-depth reflection, not a "blue sky" boilerplate stuffing!

My Final Reflection Journal on Impacts of Semester

In this section please post a full 2 page Journal, reflecting on what you learned in the semester.

Journal should be an in-depth reflection on your service to AHRC New York City, not a "blue sky" boilerplate stuffing in order to get what you might believe to be an A Final Grade!

My Semester of Service at AHRC New York City

- My Certificate of Recognition of Service

In this sub-section please post your Certificate of Recognition of Service that you will be receiving from AHRC New York City.

This will be a great document to have posted to your e-Portfolio system!

- My Photograph of Me Receiving Certificate of Recognition from Director of AHRC New York City - Education Services (ES)

In this sub-section please post a color photograph of you receiving your Certificate from the Director.

My Other Service During or Since Semester - What I have Been Doing in Service (Optional)

In this section please optionally post any information, if not color photographs, of other service in the neighborhood or in the university that you are proud of.

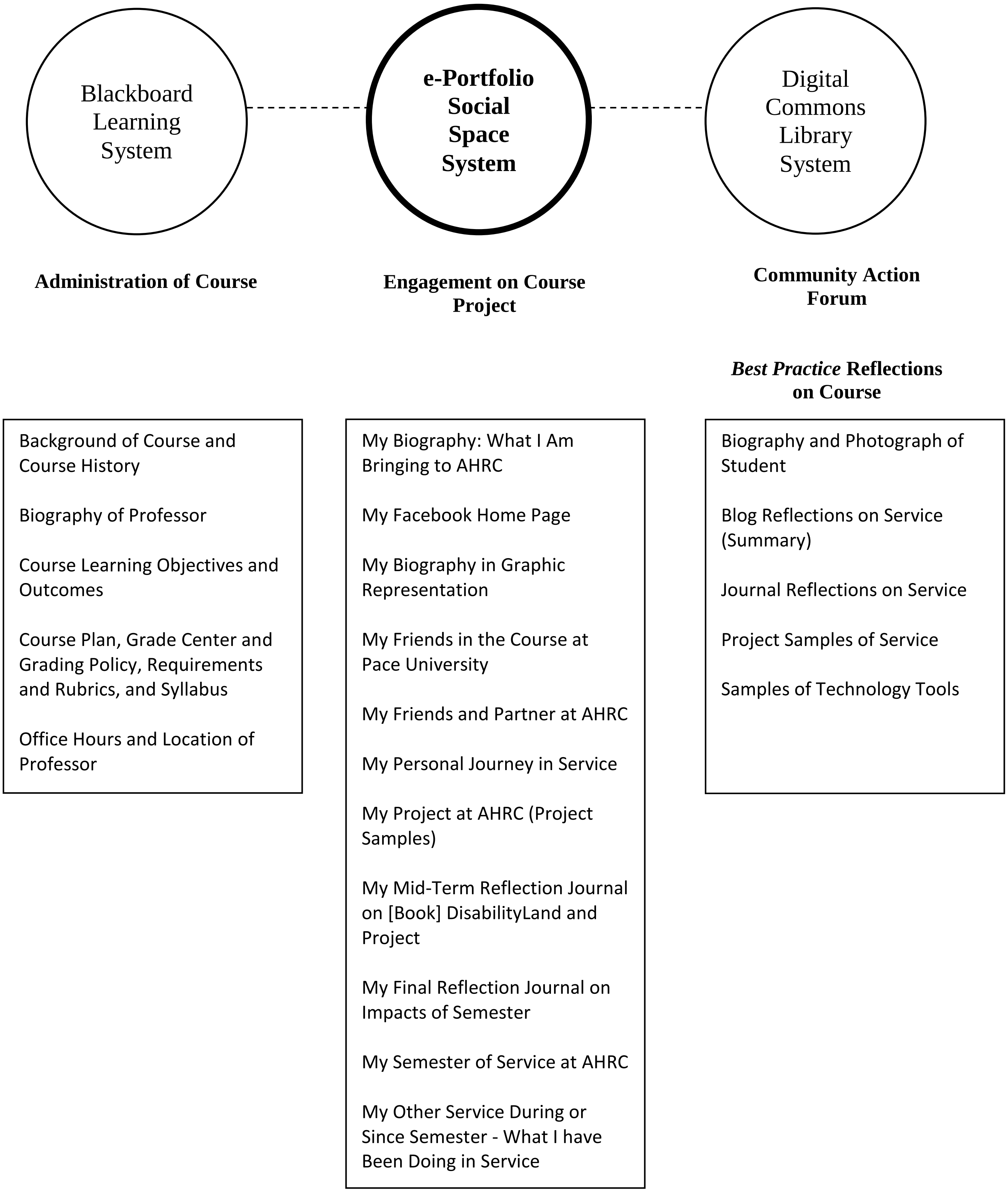
You might update this section as you pursue your studies in the university.

Rubrics Summary

Final Grades in CIS 102W CRN 21354 are based on below:

- Completion of Full Presentation Project;
- Completion of 14 Blogs in Conformance with Above Guidelines;
- Completion of 14 Blogs in Conformance with Above Due Dues (Class Day Mid-Nights)
  [Lateness is Penalized at 5% per Blog Item Lateness on Final Grades];
- Completion of Mid-Term Reflection Journal (DisabilityLand);
  and
- Completion of Final Reflection Journal.

Figure 1: Dimensions of e-Portfolio System as a Learning Management System in Community Engagement Course



An Interdisciplinary Learning Experience: The Creation of a Robot Dance

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Abstract

Students are engaging technology as a means to convey their creativity, artistic design, and appreciation of the Arts. In this paper, we share our experiences regarding an interdisciplinary project between students in an Information Sciences and Technology course and students in a General Education Arts course. Students were tasked with creating the digital musical scores and writing Java applications for the robot movements. The design and implementation of the choreography would be the bridge between discipline areas. The final product was a robot dance where the movements of robot couples were synchronized to the rhythm of the music. Active-learning exercises were utilized to expose students to a variety of music theory, animation and programming components that together provided the foundation for this project. Students used the respective software applications to realize a design in music or choreography and implement a solution. Iterative development coupled with various forms of visual and audio feedback enhanced the student learning experience.

Keywords: Interdisciplinary Project, Java, Animation, Music, Lego Mindstorms, Sibelius

1. MOTIVATION AND RELATED WORKS

Computing technology can be utilized to enhance our creativity and the learning process. When focusing on creativity in a project, one needs to be able to communicate and exchange ideas in a constructive and defined manner. To be productive, members of an interdisciplinary team must share a common vocabulary, have a common understanding of the project vision, establish goals, and constructively evaluate the efforts of each team member while working together to develop the final product (Mamykina, Candy, & Edmonds, 2002).

Within academia, faculty are seeking to include interdisciplinary projects with a significant computational component into the curriculum to enhance collaboration between computer science and other disciplines such as engineering, physics, chemistry, arts, and the social sciences. Building bridges between academic areas encourages students to explore, build hypotheses, experiment, development critical thinking for problem solving (Barr, Liew, & Salter, 2010). Replacing the traditional introductory computer science course in the curriculum with an interdisciplinary and "connected" pair of courses in creative arts, humanities, history, math and computer science, natural sciences, and social sciences has resulted in an increase in female enrollments, retention in computing, and new energy for interdisciplinary research opportunities. Connecting with Art courses in the curriculum includes design (creativity) and development (computational thinking) (LeBlanc, Armstrong, & Gousie, 2010).

Students should have opportunities to engage in interdisciplinary undergraduate research projects where they can build confidence and enhance their learning. Barker completed an interview study of both faculty research mentors and undergraduates that analyzed the organizational, social and intellectual conditions under which undergraduate research was being conducted (Barker, 2009). Barker observed that undergraduate research projects in science, technology, engineering, and mathematics (STEM) have benefits such as "improved retention in both the major and discipline-related careers; ability to work independently and to communicate well with a team; increased confidence in academic knowledge and technical skill; broader awareness of the discipline; and awareness of career opportunities and support for making career choices" (Barker, 2009 p.1-2).

Interdisciplinary teaching and interpretation of technology for various applications provides a means to maintain a computer workforce for the nation's economic, cultural, and democratic vitality. The use of robotics allows one to achieve this goal by integrating technology and software development with art, physics, mathematics, and cognitive science (Weiss & Overcast, 2008). Weinberg (2005) presents a summary of an undergraduate course in robotics that focused on developing group dynamics and teamwork skills in multidisciplinary teams. leJOS NXJ (leJOS Team, 2007) and LEGO® MINDSTORMS® (The Lego Group, 2012) were utilized in an advanced software engineering project to provide experiences with remote device interfaces, multi-threading and network communications (Lew, Horton, & Sherriff, 2010). When students develop software applications and music compositions, they follow a similar development process that includes requirements definition, design, implementation and test/debug phases (Smarkusky & Toman, 2009).

In the remaining sections of this paper, we specify technologies that were selected for the completion of the music and animation components of our interdisciplinary project. We then describe the discipline and team-based tasks that were required for the completion of the robot dance, followed by a discussion of the class presentation and project assessment. We conclude with a summary of student feedback, comments and lessons learned.

2. MUSIC AND ANIMATION TECHNOLOGIES

Sibelius

Sibelius (http://www.sibelius.com) is music notation software that provides users with the ability to insert and playback a digital musical score, refer to Figure 1. Users have the ability to create a musical score from scratch via the selection of the staff, key signature, time signature, instruments, etc.

Figure 1. Digital Score in Sibelius

Using a point-and-click interface, users can insert notes, musical nuances, symbols, lyrics, and text. Musical sequences for a variety of standard and non-standard instruments can be added to the score. This tool is equipped with digital playback where a playback indicator displays the bar number and the timeframe as the music is playing, providing audio and visual feedback to the user.

LEGO MINDSTORMS NXT

The LEGO MINDSTORMS NXT, shown in Figure 2, has strong community support and provides an extensible platform (The Lego Group, 2012). There is an abundance of documentation available for the LEGO MINDSTORMS and they tend to be less expensive that other robot kits. The kits provide flexibility in that they can be assembled into a variety of configurations based on the project being completed. The NXT brick includes four sensor ports ('1', '2', '3', and '4') and three input ports ('A', 'B', and 'C'). LEGO

Figure 2. LEGO® MINDSTORMS® NXT

offers a wide variety of sensors to include Sound Sensor, Light Sensor, NXT Color Sensor and Ultrasonic Sensor. Communication between the computer and the brick was accomplished via a USB cable connection.

leJOS NXJ

leJOS NXJ is a Java programming environment for the NXT that was originally created from the TinyVM project, which was an implementation of a Java Virtual Machine for LEGO MINDSTORMS RCX system (leJOS Team, 2007). This firmware is used to replace the NXT MINDSTORMS factory-loaded software, which includes a drag-n-drop environment for programming. This leJOS NXJ environment includes a Java Virtual Machine, a library of classes that implement the NXJ Application Programming Interface (API) for execution on the brick, a library of Java classes for computer programs that communicate with the brick via USB or Bluetooth, PC tools for debugging and flashing the firmware, and the capability to compile, link and upload programs and other files to the NXT brick. The original firmware can be reloaded at any time using the supplied LEGO software.

The benefits of using leJOS NXJ include the use of a high-level Java programming language, support for object-oriented programming, an opportunity to use open source software, and development via NetBeans (www.netbeans.org) or Eclipse (www.eclipse.org) Integrated Development Environment (IDE) with associated plugins for each environment. For the more advanced Java Developer, it supports multi-threading, listeners and events, support for the playing of 8-bit WAV files, and it provides opportunities for challenging, multimedia-based and problem-solving projects.

3. ROBOT DANCE REQUIREMENTS

In this section, we discuss the requirements of our robot dance project that was completed by eighteen students in a Fundamentals of Music Theory course and eight students in a Distributed Computing course. The project duration was four weeks with Music students involved for the entire project and Information Sciences and Technology (IST) students participating for the final three weeks. A snapshot of a robot dance is shown in Figure 3.

Figure 3. Robot Dance Snapshot

Discipline Specific

Music students utilized Sibelius for the creation of the digital musical score. The Music Theory course introduced students to the fundamental concepts of music and music terminology (pitch, melody, rhythm, time signatures, major and minor scales, key signatures, intervals, chords, and proper setup of a musical score) which prepared them for this interdisciplinary robot dance project. Using these concepts, students were given selected piano sheet music in which they entered the notes from the sheet music with exactness into Sibelius using the point-and-click interface. The sheet music score was enhanced further by adding additional instruments such as trumpet, flute, clarinet, guitar, bass guitar, and drums using plug-ins that are integrated within Sibelius. Students have full control of their musical score by being able to control dynamics, tempo, and other musical nuances of their playback. Once the digital musical score was complete, it was exported to a WAV format. The Sibelius and WAV files were uploaded to the on-line team space for use by the IST student to utilize in the timing of the music and the synchronization of the dance steps that were created.

In preparation for the robot dance project and while the Music students were creating the Sibelius and WAV files, the IST students were becoming familiar with the leJOS Application Programming Interface (API). IST students would need to implement the choreography using Java for deployment on the leJOS NXJ firmware for the LEGO MINDSTORMS NXT platform. We assigned a Robot Maze project where IST students had an opportunity to learn how to interact with the leJOS interface using Java as well as compile, link, upload and execute programs on the NXT. Students experienced Java Threads, interaction with various sensors, but most importantly how to pilot the robot which included moving forward and backward, turning a specified number of degrees, moving in an arc motion, etc. This opportunity prepared the IST students with the knowledge they needed to communicate with the Music students when discussing the capabilities of creating the choreography for the robot dance. Once the maze project was complete, IST students focused their attention on the robot dance.

Interdisciplinary Team

We selected students from each course and assigned interdisciplinary teams based on student performance from previous course assignments. Each team consisted of one IST student and two or three Music Theory students. Team spaces were setup in an on-line course management system for students to post their Sibelius files, WAV files, choreography design, and the Java source code files. Each team was assigned a different song for this project.

The next step of this interdisciplinary project was having an IST student listen to a sound clip sample of the assigned song before their initial meeting with the music students. Since the music students were creating digital musical scores in Sibelius of these songs, the final product would sound slightly different due to additional instruments (bass, drums, etc.) and may have a variation of tempo (how fast/slow the music is played). The choreography would need to match the length of the team's cover version and would also need to be synchronized with the timing of the music created by each team.

Each team worked on the design phase of the choreography for the robot dance. Students were informed that each robot couple (two robots) should remain on the dance floor (6' X 12') at all times, the robots were not to come in contact with each other and that the wheels of the robot were to be in contact with the dance floor or other solid surface at all times. Both Music and IST students defined the dance routine to include right and left turns, arcs, spins, forward and backward movements and the starting and ending points in the song for each movement and the duration of each movement. During class meetings and between meetings, the IST student would work to implement these motions in Java so that the identified robot movements would be synchronized to the timing of the music. Timing of the movements was critical to the quality of the dance. Students utilized the playback indicator in Sibelius for the proper timing of the music to be synchronized with the robot's moves. Together the IST and Music students observed the robot movements, listened to the music, and precisely documented the start/stop times for each movement as they followed the design of the choreography. Once the movements for the first robot were complete, the IST student then needed to write a program to mirror the choreography for the second robot, altering the movements, rotations and directions, and yet keeping the timing the same.

Similar to patterns in musical scores, the IST student recognized patterns in the choreography and the timing of the movements. This provided a unique learning opportunity for the IST students as they realized the importance of threads and the writing object-oriented methods for each routine with parameters for time, duration, direction, or rotation for various movements.

As the teams worked side-by-side on the completion of this project, we began to see the communication between interdisciplinary members come together using a common language to describe the dance steps and how this was to be accomplished. Similar to the comparison presented in Do & Gross (2007), the music student is not expected to be a programmer, and the programmer is not expected to be a music student. Each member of the interdisciplinary team utilized their strengths for the success of the project. Teams were very excited about the outcome of the robot dance project and would often stay after class to work on their projects so that their dance would be better than other teams. During this process, the IST student appreciated the time and effort that the Music student had put into the digital musical score and the Music student appreciated the attention to detail that was needed for the creation of the choreography.

Presentation and Assessment

The completed project was presented to students from both classes and invited guests from the campus community. To provide the proper ambiance for the Robot Dance Party, we reserved a conference room; setup the dance floor area surrounded with tables and chairs; and provided a sound system and data projector for the playing and display of the digital musical score while the dance was being performed.

Grading criteria for assessment of the digital music scores included correct staves, key signature, time signature, notes, rhythmic durations, slurs, expressive and tempo markings, dynamics, musical symbols, correct number of measures repeat signs, etc. The addition of other instruments to the basic piano score included flute, clarinet, trumpet, saxophone, guitar, bass, and drum set. The final assessment component was the conversion of the score from a Sibelius (.sib) file to a WAV file. The IST student efforts were assessed on the creativity and complexity of the choreography for two robots; synchronization of movements between two robots; synchronization (timing) of movements to the music file for both robots; overall appearance and quality of the choreographed dance for the two robots; and submission of project deliverables and student feedback.

This project included an element of creativity that allowed students in both disciplines an opportunity to work together towards a common goal. By providing students with an opportunity for participatory learning and defining an assessment that included a set of learning objectives linked to grading criteria, we could level the playing field for different types of students (Carter, Bouvier, Cardell-Oliver, Hamilton, Kurkovsky, Markham, McClung, McDermott, Riedesel, Shi & White, 2011). Assessment criteria for the music and animation components were provided to the students to help identify the roles of each team member, provide a guideline for project success, and promote a positive learning experience for students in an interdisciplinary team.

4. FEEDBACK AND LESSONS LEARNED

After the project was completed, we asked students to complete a survey to evaluate the creative nature of the robot dance project. Our survey used a 5-point Likert Scale (where 1 = Strongly Disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, and 5 = Strongly Agree). All 26 students (18 Music and 8 IST) completed the surveys. The survey results for the Music and IST students are shown in Table 1 and Table 2, respectively, of the Appendix. The percent of positive responses noted in the table include all responses with Agree or Strongly Agree.

Students in both disciplines, Music (100%) and IST (100%) had positive responses regarding working with students in other disciplines and that both disciplines worked together as a team. Although 61% of the Music students thought of themselves as creative in ART, only 39% had positive responses about being creative when using Technology and/or Software. Similarly, 100% of the IST students thought of themselves as being creative when using Technology and/or Software, but only 38% had positive responses about being creative in ART. As predicted students felt more strongly about the concepts and focus of the course in which they were enrolled.

It is interesting to note that Music students had a 100% positive response about this project being a creative learning experience, but only 71% of the IST students felt this project was a creative learning experience. This reinforces the statement that computing technology can be utilized to enhance creativity and the learning process in interdisciplinary areas. Although students in both disciplines thought of themselves as being more creative in their discipline, students in both Music (53%) and IST (50%) had positive responses about this project allowing them to improve their creative skills. Both Music and IST students agree that this project should be offered again, with 83% and 88% providing positive responses.

Utilizing software tools for both the music and animation components allowed students to correlate real world activities with those contained in the final robot dance. The extent to which students were pleased with their final product had a direct correlation with the students ability to communicate with each other in the team and translate what they had completed with the music composition to that which was to be developed for the robot choreography(Yardi, Krolikowski, Marshall, & Bruckman, 2008). This collaborative and interdisciplinary project was a positive learning experience for students in both departments. Statements of lessons learned from the IST students follow:

- *"The choreography project specifically has provided interaction with students who did not have a programming background and therefore provided a more realistic experience for a project. Working out a solution that satisfies the expectations of someone who may not understand the complexity and hurdles [of programming] that could prevent the completion of the project provides a real world aspect that can be lacking in other projects. "*

- *"One of the things I did learn while doing this project was the similarities between Java code and music as a whole. I play guitar and have learned repeated riffs in songs before, but I never really viewed them as functions in a program until working on this project. I always viewed myself as uncreative because I can't write music if my life depended on it, but seeing this correlation between music and code really sheds a new light on things. This project helped to show me that I am creative. I'm just creative through my own outlet, not through the standard views of creativity."*

- *"This project has given me so much confidence and knowledge on how to work with a new API. Doing this interdisciplinary project, I have gained the knowledge of not only the new API but also something that I wouldn't have learned as an IST student, and that would be music. At first when we got this project, I thought it would be really easy and it wouldn't take that long. But, after implementing the choreography and starting to synchronize the robots with the music, it became harder and harder."*

In summary, this interdisciplinary project provided students in both Music and IST courses with an opportunity to become familiar with terminology and concepts from both disciplines. Students quickly learned that the creation of digital musical scores and the Java programs that controlled the choreography both required attention to specific detail and the following of a very similar development process. In identifying tools for application of concepts, both departments preferred software that would provide instant feedback to students during project development. Understanding the importance of being patient in learning the step-by-step process for the creation of successful projects in these disciplines is essential. By using Sibelius, we have found that students are trained to look for specific details that are required for the creation of a correct and complete musical score, which enforces that which is taught to students when they are programming in Java for the leJOS NXJ firmware on the LEGO MINDSTORMS platform for the robot choreography. The success of this project and support from student feedback warrants offering it again in the future. By broadening the scope of this project we can add more technical requirements to include Bluetooth communication between robots, or utilizing the LEGO MINDSTORMS software with the drag-and-drop interface to expose students who are not familiar with programming in Java to robots and music. The robot dance can be extended to other courses, taught in summer camps, or demonstrated during recruiting events to enhance student interest in IST-related degree programs.

5. REFERENCES

Barker, L. (2009). Student and Faculty Perceptions of Undergraduate Research Experiences in Computing. *Transactions on Computing Education* 9(1), Article 5. March 2009, 28 pages. DOI=10.1145/1513593.1513598 http://doi.acm.org/10.1145/1513593.1513598

Barr, V., Liew, C.W., & Salter, R. (2010). Building bridges to other departments: three strategies. In *Proceedings of the 41st ACM technical symposium on Computer science education* (SIGCSE '10). ACM, New York, NY, USA, 64-65. DOI=10.1145/1734263.1734285 http://doi.acm.org/10.1145/1734263.1734285

Carter, J.,Bouvier, D., Cardell-Oliver, R., Hamilton, M., Kurkovsky, S., Markham, S., McClung, O.W., McDermott, R., Riedesel, C., Shi, J., & White, S. (2011). Motivating all our students?. In *Proceedings of the 16th annual conference reports on Innovation and technology in computer science education - working group reports* (ITiCSE-WGR '11), Liz Adams and Justin Joseph Jurgens (Eds.). ACM, New York, NY, USA, 1-18. DOI=10.1145/2078856.2078858 http://doi.acm.org/10.1145/2078856.2078858

Do, E.Y., & Gross, M.D. (2007). Environments for creativity: a lab for making things. In *Proceedings of the 6th ACM SIGCHI conference on Creativity & cognition* (C&C '07). ACM, New York, NY, USA, 27-36. DOI=10.1145/1254960.1254965 http://doi.acm.org/10.1145/1254960.1254965

LeBlanc, M.D., Armstrong, T., & Gousie. M.B. (2010). Connecting across campus. In *Proceedings of the 41st ACM technical symposium on Computer science education* (SIGCSE '10), ACM, New York, NY, USA, 52-56. DOI=10.1145/1734263.1734280 http://doi.acm.org/10.1145/1734263.1734280

The LEGO Group. (2012). http://mindstorms.lego.com/en-us/whatisnxt/default.aspx

leJOS Team. (2007) http://lejos.sourceforge.net/

Lew, M.W., Horton, T.B., & Sherriff, M.S. (2010). Using LEGO MINDSTORMS NXT and LEJOS in an Advanced Software Engineering Course. *Proceedings of 23rd IEEE Conference on Software Engineering Education and Training,* 121-128.

Mamykina, L., Candy, L., & Edmonds, E. (2002). Collaborative creativity. *Communications of the ACM* 45(10), 96-99. DOI=10.1145/570907.570940 http://doi.acm.org/10.1145/570907.570940

Smarkusky, D.L., & Toman, S.A. (2009). An interdisciplinary approach in applying fundamental concepts. In *Proceedings of the 10th ACM conference on SIG-information technology education* (SIGITE '09). ACM, New York, NY, USA, 224-228. DOI=10.1145/1631728.1631800 http://doi.acm.org/10.1145/1631728.1631800

Weinberg, J.B., White, W.W., Karacal, C., Engel, G.,& Hu, A. (2005). Multidisciplinary teamwork in a robotics course. In *Proceedings of the 36th SIGCSE technical symposium on Computer science education* (SIGCSE '05). ACM, New York, NY, USA, 446-450. DOI=10.1145/1047344.1047488 http://doi.acm.org/10.1145/1047344.1047488

Weiss, R., & Overcast, I. (2008). Finding your bot-mate: criteria for evaluating robot kits for use in undergraduate computer science education. *J. Comput. Small Coll.* 24, 2 (December 2008), 43-49.

Yardi, S., Krolikowski, P., Marshall, T., & Bruckman, A. (2008). An HCI Approach to Computing in the Real World. *Journal on Educational Resources in Computing,* 8(3), Article 9, October 2008, 20 pages. DOI=10.1145/1404935.1404938 http://doi.acm.org/10.1145/1404935.1404938

APPENDIX

Table 1. Music Perspective Survey Results (1=Strongly Disagree; 5 = Strongly Agree)

Project Evaluation by MUSIC Students	Mean	Std Dev	% of Positive Responses
This project was a creative learning experience	4.33	0.49	100
I enjoyed working with students in other disciplines	4.39	0.50	100
Both MUSIC and IST students worked together as a team to create a successful and complete project	4.50	0.51	100
I think of myself as a creative person in ART	3.56	1.20	61
I think of myself as a creative person when using TECHNOLOGY and/or SOFTWARE	3.33	1.03	39
This project has allowed me to improve my creative skills	3.47	1.01	53
I would recommend offering this project again	4.11	0.96	83

Table 2. IST Perspective Survey Results (1=Strongly Disagree; 5 = Strongly Agree)

Project Evaluation by IST Students	Mean	Std Dev	% of Positive Responses
This project was a creative learning experience	4.00	0.82	71
I enjoyed working with students in other disciplines	4.38	0.52	100
Both MUSIC and IST students worked together as a team to create a successful and complete project	4.25	0.46	100
I think of myself as a creative person in ART	3.13	1.25	38
I think of myself as a creative person when using TECHNOLOGY and/or SOFTWARE	4.38	0.52	100
This project has allowed me to improve my creative skills	3.50	0.93	50
I would recommend offering this project again	4.13	0.64	88

Flipping Excel

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Abstract

The "flipped classroom" model has become increasingly popular in recent years as faculty try new ways to engage students in the classroom. In a flipped classroom setting, students review the lecture online prior to the class session and spend time in class working on problems or exercises that would have been traditionally assigned as homework. The ability to easily create and consume multimedia on personal computers, tablets, smart phones, and personal media players, and the increased availability of web-based tools for collaboration and communication are two factors that contribute to the popularity of the flipped classroom. This paper presents an implementation of the flipped classroom pedagogy in a first-year introductory Information Technology course, specifically focusing on how these techniques were used to facilitate students' experiences learning Excel concepts. A survey given to students in three sections of the course suggests that students found the instructional methods captured their interests, challenged them, and contributed to their learning.

Keywords: flipped classroom, inverted classroom, Excel, active learning, undergraduate education

1. INTRODUCTION

The flipped (or inverted) classroom has become a popular pedagogy in secondary and tertiary education for teaching science, mathematics, and other courses. In a flipped classroom, students watch or listen to recordings of class lectures on their computers, tablets, smart phones, or personal media players outside of class, leaving class time to engage in learning activities that might otherwise be assigned as homework. (Knewton.com, 2011)

Bergman and Sams (2012) are often credited with operationalizing the flipped model in their high school science classroom in 2007 when they recorded narrations of their PowerPoint presentations as podcasts for students who missed class. The use of electronic equipment to record classroom lectures, however, has been found as early as 1977. Gibbons, Kincheloe, and Down (1977) reported that tutored videotape instruction through the use of "unrehearsed, unedited video tapes of regular classroom courses, which can be produced at very low cost" (Gibbons, Kincheloe, & Down, 1977, p. 195) enhances student learning. Among their reasons cited, students can review the tapes at their own pace and listen again to those sections that present important or complex concepts.

Day (2008) introduced the term "web lectures" to refer to "multimedia presentations that integrate talking head and torso video, audio, lecture slides, table of contents, and navigation controls, which are made available via the web (streaming or download)" (Day, 2008, p. 3). The subject of the web lecture is not rehashed in the classroom but rather extended or applied to allow for new learning opportunities.

This paper reports on an implementation of the flipped classroom in an introductory Information Technology classroom through the use of student-generated screencasts (screen video recordings) that demonstrate spreadsheet techniques and concepts. A student survey suggests that students embraced this instructional model and the classroom interactions it enabled. This paper focuses on developing techniques for structuring a flipped classroom to teach spreadsheet concepts and shares student reactions related to engagement after participating in this active learning experience.

2. VARIATIONS IN IMPLEMENTING THE FLIPPED CLASSROOM

Several recent studies (Day, 2008; Strayer, 2007; and Demetry, 2010) have focused on the effectiveness of the flipped classroom on student learning and the additional opportunities for collaboration and problem solving that it enables.

The literature shows several variations in how individual instructors flip their own classrooms.
Many instructors record their own lectures (or have them recorded), while instructors of mathematics, science, history, finance, and other disciplines frequently make use of some of the 2600 videos from Khan Academy[i] as resources for their flipped classrooms. (Houston & Lin, 2012) Rather than providing video lectures, Demetry (2010) provides lecture notes for students to read lecture notes at home prior to the class session. This helps meet the goal of increasing "time on task" to complete course-related activities. Student teams check in by responding to "clicker questions" to report their progress as they work on the exercises.

Day and Foley note that web lectures are "purposefully kept at around 20 minutes in length to help maintain the attention of the viewer." (Day & Foley, 2006, p. 196) They remark that the same material would likely take twice as long to deliver in the classroom because there are no interruptions for questions or announcements.

Given the documented effectiveness of the flipped classroom model on learning across disciplines and grade levels and the variety in methodologies for implementing it, these research questions emerged for creating a flipped environment in the Information Technology classroom:

- Will students find peer-generated screencasts an effective method for demonstrating spreadsheet concepts?
- Will students of a variety of academic abilities embrace the flipped classroom model?
- Can a flipped classroom experience also encourage students to use web-based collaboration tools?

3. FLIPPING EXCEL IN THE INFORMATION TECHNOLOGY CLASSROOM

IT 101 (Introduction to Information Technology and Computing Concepts) is an introductory IT course required of all first year students at Bentley University, a business university located in Waltham, MA, USA. During the Spring 2012 semester, the author taught three sections of the course to academically varied groups of students:

- a day honors section, for students enrolled in the honors program, chosen because of their high scholastic abilities;
- a day accelerated section, offered to students who self-selected to be this section because of their interest in technology; and
- an evening section, open to all full-time and part-time students.

The evening section had a mix of 35 traditional and older students and met once per week for 150 minutes, while the honors and intensive sections each had 24 students and met for two 75-minute sessions each week.

The course covers digital literacy topics, basic web development, maintaining laptops, wireless networking, and current web trends. Approximately ten of the 24 class meetings each semester introduce beginning and intermediate Excel topics, so when considering how to implement a flipped classroom approach in IT101, flipping Excel seemed to be a promising choice. For the day sections which met twice weekly, most Mondays were designated as Excel days, and Wednesdays were spent covering other course content. In the evening section, usually the first half of class was spent on other course content, and the second half of class spent on Excel topics in the flipped classroom approach. The only reason for teaching Excel during the latter half of a night class was a practical one: after completing the group exercise, students could leave at the end of class.

The content, structure, and exams for all three sections were virtually identical. The honors and accelerated sections had more involved assignments than the evening students, and these students often brought in external readings for class discussion. The graded Excel assignments were the same, both in class and out of class, for all three sections. The depth of discussion, number and variety of questions, motivation of students, and degree of help and explanations that the instructor provided varied greatly between the sections.

All students must complete exercises from a textbook companion web site to demonstrate their mastery of the course topics. Students submit their completed assignments online and, soon afterward, receive an automated report summarizing their scores and indicating which steps are correct. Students have up to five attempts to complete these exercises; their highest score counts toward their final grade.

Prior to the flipped classroom approach, the instructor would explain Excel concepts in class or demonstrate a tutorial from the textbook during class as students tried to follow along on their laptops. They would then go home to complete the mastery exercises.

In the flipped approach, when students watch the instructional videos before class, there is no in-class demonstration or lecture by the instructor. Students immediately get to work completing an in-class group activity. Also, the instructor is readily available to help students complete these exercises; whereas at home, students are on their own or need to visit the tutoring lab or the instructor at a later time if they require assistance in order to complete the assignments.

These guidelines influenced the implementation of the flipped IT 101 classroom, whose 75-minute sessions usually followed this structure:

- five minutes: welcome and announcements
- five minutes: quick quiz based on videos
- five minutes: explain in-class activity
- 40 to 45 minutes: complete the in–class activity in groups
- 15 to 20 minutes: debrief, where each group shares what they did, how they solved a problem, problems they encountered

This structure creates an active learning experience where "learners participat[e] in open-ended, learner-centered activities that involve practical, meaningful application of the concepts of interest; collaborative problem solving and opportunities for public/personal articulation and reflection are also important" (Day, 2008, p. 27).

Creating Screencasts

For this study, the instructor reached out to student tutors in the CIS department's learning lab to create two or three instructional screencasts per chapter for IT 101 students to watch. Tutors worked with the instructor to identify and discuss content for the videos. Their work as tutors during previous semesters or their own experience learning Excel themselves in IT 101 made them uniquely qualified to create the instructional videos. They were familiar with, and therefore able to address many frequently asked questions on Excel topics. There were no limitations as to style or format of the videos; students could be as creative as they wished. The only requirements were that each video included a common title graphic identifying its topic and a request to keep the length to between seven and ten minutes, as previous research in student-created podcasts has shown this duration to be within the attention span of first-year college students. (Frydenberg, 2008)

Students used a variety of free web tools to create their videos[ii], posted their videos to a common YouTube channel and embedded them on a web site available to all IT 101 students.[iii] Videos were usually posted the week prior to when students would complete activities based on them during class.

Quick Quizzes for Evaluation

Most classes began with a quick five-question, five-minute, multiple-choice quiz based on the week's videos. The instructor used Blackboard, a learning management system, to administer the quizzes online so that they could easily be timed, and automatically graded.

Quizzes motivated students to watch the videos because each counted a small amount toward final grades. The quizzes also helped learners check their understanding of key concepts prior to doing the hands-on, in-class activity, and as such bridged the gap between the outside-the-classroom learning and inside-the-classroom application of that learning.

Four of the questions on each quiz were related to spreadsheet concepts or techniques explained in the video. One question was always based on the video itself, designed such that students watched the video would remember the answer. For example, in a video about creating graphs, the data being graphed included information about popular songs, and the student who created the video creatively included a short audio clip of the Macarena at the start of the video. A question on the quiz asked "What song was playing at the start of the video?" The assumption is that students who watched the video would remember this, even if they did not understand anything about the spreadsheet lesson that the video was trying to convey.

Collaboration and Just-In-Time Learning in the Classroom

Students worked in groups of three to six (depending on class size and configuration) to complete the in–class exercises. The two day-sections of the class met in an experimental collaborative classroom, where students sat in groups of four at large tables equipped with a shared computer and keyboard, and a large screen monitor, as shown in Figure 1.

Figure 1. Flipping in a Collaborative Classroom.

In the evening section, students met in a lecture style lecture classroom. They worked in groups of three, rearranging their chairs to see their partners, or forming clusters to support their collaboration efforts, as shown in Figure 2.

In cases where students could not see each other's screens, they use join.me[iv] to share their screens with each other. Students also used join.me to share their screens with the instructor's podium computer so that it could be projected for all the class to see as they discussed their accomplishments during the debriefing portion of the class.

Figure 2. Flipping in a Lecture Style Classroom.

During the in-class group activity, the instructor would walk around the room from group to group answering questions and providing assistance. Sometimes if several groups had the same problem or needed to learn the same concept, the instructor would call a time out and provide just in time explanations of the key concept needed to continue the lesson.

The Reader, the Doer, and the Checker

Each in-class activity was designed so students could take on each of three roles in their groups: the reader, the doer, and the checker.[v] The reader and the checker would load the description of the exercise on their laptops. The reader would read aloud the required task or step to the doer; the doer would try to do the step, and the checker would help the doer (if necessary, or able) and confirm that the doer completed the step correctly. Students alternated roles of reader, doer, and checker while completing the assignment so that each student could experience each of the roles at least once during the exercise. These roles provided a structure for the groups to begin their work together.

The rationale for creating these roles is as follows:

- by speaking the words aloud, the reader has the opportunity to use the language of Excel when communicating with the doer and the checker;

- the doer has to listen and follow the instructions, and isn't distracted by switching screens or looking on a printed sheet with instructions to see what to do next;
- the reader and the checker can provide assistance to the doer if necessary, and the checker is responsible for making sure the step looks good before the group continues to the next step.

The first task in each assignment instructed students to create a worksheet with the names of their group members. Instructions generally decreased in detail as the activity progressed in order to promote problem solving. In this way, steps are task-based rather than keystroke based, so students are learning how to solve a problem, without being caught up in the details of what to click or select next.

Students worked in the same groups throughout the semester and created a shared folder on Dropbox[vi] to easily access their group's work products. The in-class activities were not graded per se, but students received credit for completing them, and lost credit if they did not. Students who were absent had 48 hours to complete the assignments individually outside of class in order to receive credit. Students had to electronically submit their own individual copy of the file that their group created in order to receive credit. A portion of an in-class activity is shown in Appendix I.

4. RESEARCH METHODOLOGY

To determine the impact of flipping the IT classroom, the author offered a voluntary online survey at the end of the Spring 2012 semester to all 66 students (40 male, 26 female) enrolled in three academically diverse sections of IT 101 (22 Honors, 17 Accelerated, 27 Evening). All sections were taught by the same instructor using the same outside-of-class instructional videos and the same in-class activities. The survey asked students for their reactions after participating in ten flipped classroom sessions on learning Microsoft Excel concepts.

Student Reaction to the Flipped Classroom Approach

Students found the flipped classroom for teaching spreadsheet concepts to be challenging and engaging. They would like to see this methodology implemented in their other classes. Said one student: "I would absolutely recommend this [approach] for all future IT 101 classes. I also feel as if this style of learning would be complementary to any sort of introductory calculus class and/or writing and literature classes. I am a strong proponent of this style of learning and feel as if it can be even more effective than lecturing when used properly and in a structured manner."

Taking time to complete the in-class activities was beneficial to most students. When asked if they would have otherwise completed the in-class activities as homework in addition to the regular homework, most students, across all sections, said they would not, as shown in Figure 3.

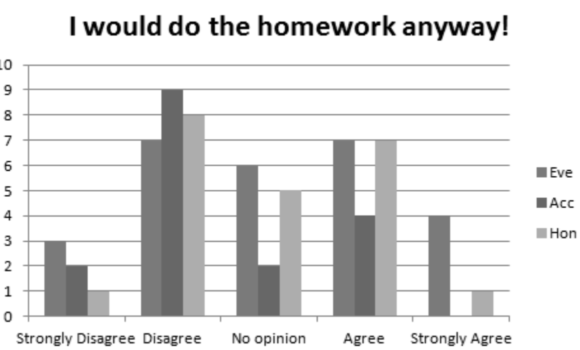

Figure 3. Value of Completing Learning Activities in Class

It is surprising that most of the supposedly "better students" in the Honors and Accelerated sections would not do the homework and encouraging that some of the evening students are conscientious enough to say they would complete it.

Effectiveness of Role Playing

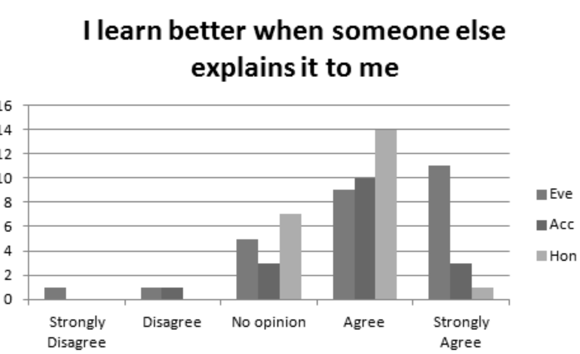

Figure 4(a). Student learning through explanations.

The evening students, more so than honors or accelerated students, claim they learn better when someone explains to them what to do, as suggested by the results in Figure 4(a). This may be because the honors and accelerated students are used to reading more.

This result is in line with students finding that taking on roles of reader (explainer), doer, and checker, add value to their learning experience, as shown in Figure 4(b). These roles allow students to interact with spreadsheet concepts through speaking, listening and responding, and watching.

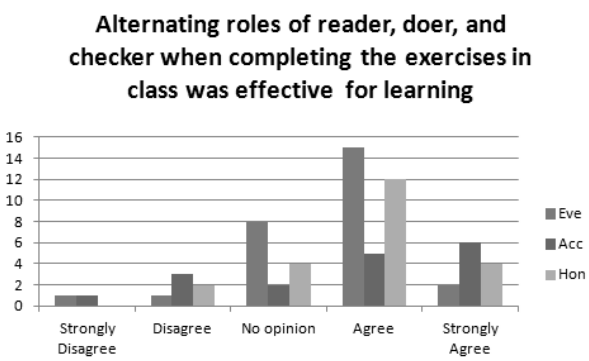

Figure 4(b). Effectiveness of Flipped IT Classroom Student Roles

Social Awareness in the Flipped Classroom

This implementation of the flipped classroom also promoted social awareness, camaraderie, and a spirit of cooperation among group members and their classmates, across all three different sections, as the survey results in Figure 5 (a-c) suggest:

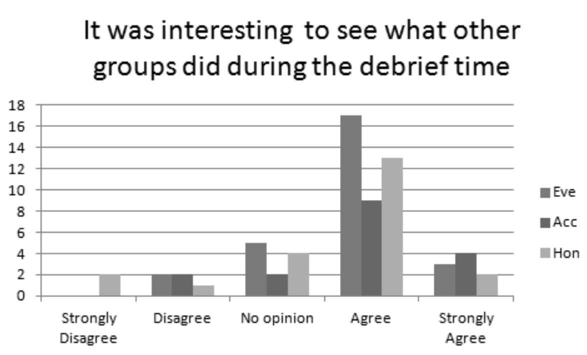

Figure 5(a). Interest in other group activities

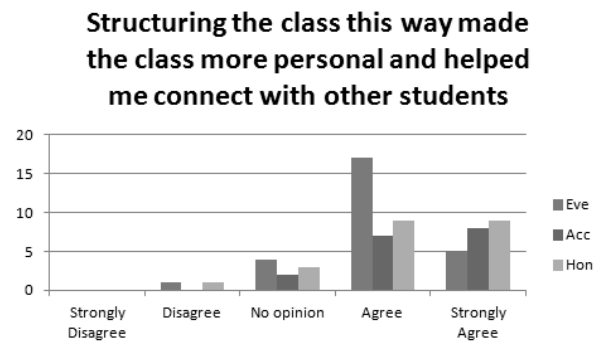

Figure 5(b). Flipping and Personalization

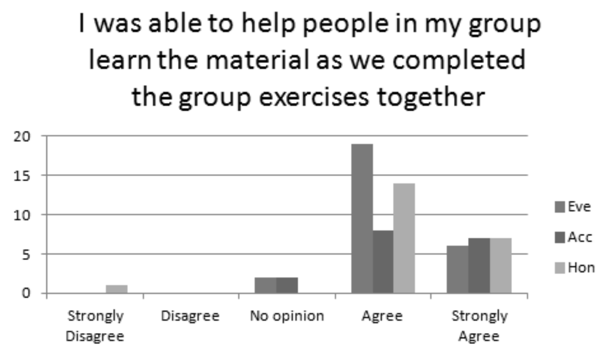

Figure 5(c). Social Awareness Factors in the Flipped Classroom

It is interesting to note that especially in the evening section, which had the largest class size (35), students found the flipped classroom a way to make the class seem more personal.

One student remarked that the composition of the groups is important, saying "My group was very helpful and each of us contributed equally which is probably why I liked the group assignments so much. If I were in a lazy group, my opinion probably would have been considerably different.

Comparing Perception of Flipped and Traditional Classroom Experiences

As shown in Figure 6, the majority of students from all sections felt that the flipped classroom helped them learn the material better or much better than had they been in a traditional classroom.

A student remarked: "Figuring out the assignments as a group on our own was just so much more engaging and helpful in learning the material, that I really don't know how a traditional classroom lecture of the material would be able to compare."

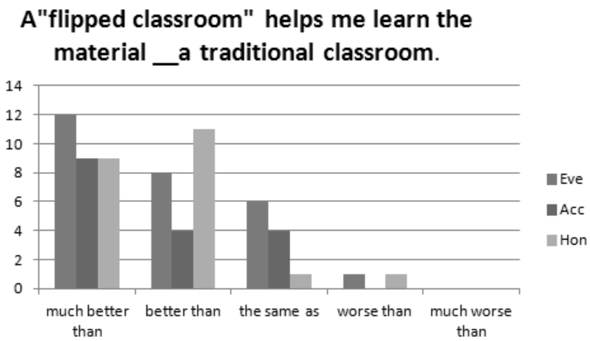

Figure 6. Student Perception of Flipped Classroom.

After completing their first flipped classroom activity, students were asked to email their responses to "How are you feeling right now?" to the Instructor. Many expressed sentiments of frustration and accomplishment, such as this:

> "There were parts of the assignment that were frustrating, but I think I got more out of it than I would have gotten out of a lecture because you had to actually know how to do the different steps and if you didn't know you had to learn it."

Instructional Screencast Videos

Across the different sections, there was not significant variation in why students watched the videos, as shown in Figure 7. The majority knew they would be quizzed and wanted good grades, others wanted to be prepared for the in-class exercises that followed.

As shown in Figure 8 the majority of students across all sections felt it was possible to convey a single concept in a video of seven to ten minutes.

Creating the videos for IT 101 students to watch turned out to be a worthwhile activity for the student tutors. One commented, "I had a great time working on the videos for the Excel tutorials! I not only had the opportunity to learn about new Excel concepts in detail but was also able to practice those I had already mastered through my own IT 101 experience."

The videos were also made available to sections of IT 101 taught by different instructors. There were 14 sections of IT 101 in the spring, most with 30 to 35 students, for a total of approximately 400 students taking the class across all sections. YouTube shows that some of the videos had as many as 240 views, suggesting that over half of the IT 101 students across all sections that semester watched them.

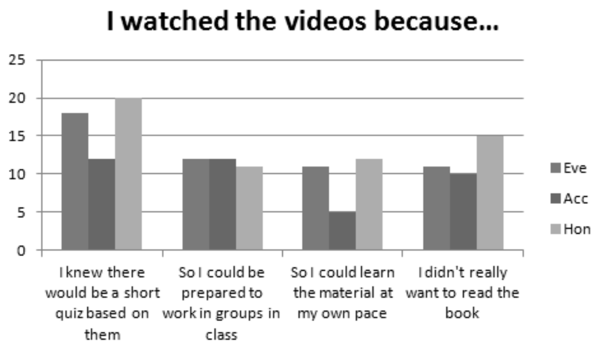

Figure 7. Reasons for watching screencasts outside of class.

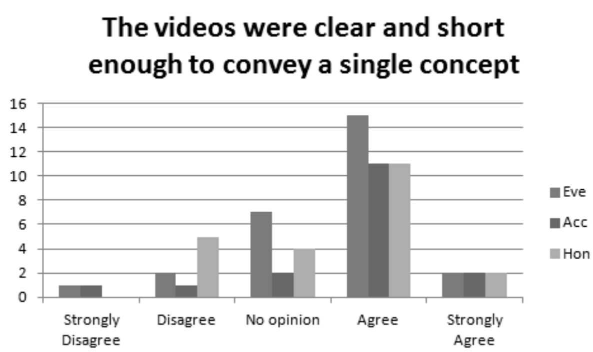

Figure 8. Clarity of Screencast videos.

Role of Instructor

Many students noted the role of the instructor had changed from a lecturer to a mentor who walked around the room and was available to help each group to provide "just-in-time" information about specific concepts or skills on an as- needed basis.

There were six groups of four students in each day section, and as many as ten groups of three or four students in the evening section.

Several of the honors and accelerated students shared the sentiments of one who noted that putting the instructor in this role brought about "a more catered learning experience without ignoring any students, and the teacher was able to push the important material without wasting time on what could be called filler material."

An evening student commented that "due to the large number of groups [in his section of the class], this method [of the instructor rotating among groups] was somewhat inefficient, and each group would have to wait their turn for assistance. Often groups may have had the same question."

5. LESSONS LEARNED

Key elements to this implementation to the flipped classroom were the screencasts to be watched before class, the quizzes which provided an incentive for watching them, and the in-class exercises and debriefing time.

The tutor-created instructional screencast videos were well received, as evidenced by the number of views they received on YouTube. The videos were made available across several sections of IT 101 (not just those of this instructor). Some of the videos received over 200 views. Given that approximately 400 students were registered for the class across all sections, this suggests that approximately half of the students saw at least some of the videos. The tutors who created these videos developed a list of best practices for doing so in the future. These include zooming in on just the section of the spreadsheet that is being featured so it is more easily visible, setting up as much as possible beforehand so that the video can focus only on key concepts, and creating a script to follow when recording the demonstrations. Keeping the length of the videos short was also helpful in being able to locate the desired content. Some videos will be redone in future semesters to improve their quality.

Students seemed to relate better to videos created by their peers in the learning lab than to those that accompanied the textbook. Students found the professional videos to be much more thorough and lacking personality.

Several of the in-class activities required students to interact with open data sets that they found online.[vii] This allowed them to explore data on topics of interest and made the exercises more relevant. Data available from online data markets[viii] often are larger and more complex than sample files that accompany textbook exercises and can be well suited for activities on filtering, formatting, or sorting. Another student had his group look at data on the spread of HIV[ix], commenting that this data would also be useful in his sociology class. This data set, and most data from http://data.worldbank.org is nicely formatted for creating spark lines.

A smaller class size and a classroom with tables rather than rows of fixed seating is more conducive for implementing a flipped classroom. The ability for the instructor to circulate among the students is crucial to their success.

6. SUMMARY

The paper presents guidelines for and student reactions to one implementation of a flipped classroom for teaching Microsoft Excel. Students in three academically different sections of IT 101 experienced the flipped classroom. This approach provides an active learning exercise in class that engages students with the material, as well as each other. There were few differences across honors, accelerated, and evening students when it came to student perceptions of the flipped classroom, reasons for watching videos, and social awareness brought about by the implementation of the flipped classroom described in this paper. This suggests that this active learning approach is accessible to all introductory students. The only thing that differed was the instructor's involvement in providing assistance to the student groups.

The structure of the flipped IT classroom described in this paper and the in-class activities also enabled students to learn about web-based collaboration tools for file and screen sharing and online open data repositories. While the paper does not claim an increase in student learning over a traditional classroom, anecdotal remarks from students suggests that they learned the material through watching the instructional videos before class and completing in-class exercises and found the experience more engaging than listening to an in-class lecture.

6. REFERENCES

Bergmann, J., & Sams, A. (2012, April 15). *How the Flipped Classroom Is Radically Transforming Learning*. Retrieved June 1, 2012, from The Daily Riff: http://www.thedailyriff.com/articles/how-the-flipped-classroom-is-radically-transforming-learning-536.php

Brown, J. S., & Duguid, P. (1998). The University in the Digital Age. In B. L. Hawkins, & P. Battin, *The Mirage of Continuity: Reconfiguring Academic Information Resources for the 21st Century* (pp. 39-60). Washington, D.C.: Council on Library and Information Resources.

Day, J. (2008). *Investigating Learning with Web Lectures .* Georgia Institute of Technology.

Day, J., & Foley, J. (2006). Evaluating Web Lectures: A Case Study from HCI. *Proceedings of CHI 2006* (pp. 195-200). Montreal: Association for Computing

Demetry, C. (2010). Work in Progress - An Innovation Merging "Classroom Flip" and Team-Based Learning. *Proceedings of the 40th ASEE/IEEE Frontiers in Education Conference* (pp. TI1-3). Washington, DC: ASEE/IEEE.

Frydenberg, M. (2008). Principles and Pedagogy: The Two Ps of Podcasting in the Information Technology Classroom. *Information Systems Education Journal , 6* (6), 11.

Gibbons, J., Kincheloe, W., & Down, K. S. (1977, March 18). Tutored Videotape Instruction: A New Use of Electronics Media in Education. *Science, New Series , 195* (4283), pp. 1139-1146.

Houston, M., & Lin, L. (2012). Humanizing the Classroom by Flipping the Homework versus Lecture Equation. In P. Resta (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference 2012* (pp. 1177-1182). Chesapeake, VA: AACE.

Knewton.com. (2011, August 29). *The Flipped Classroom Infographic*. Retrieved June 1, 2012, from Knewton: http://www.knewton.com/flipped-classroom/

Mentch, M. (2010, May 6). *The Classroom Flip: Harnessing Technology to Support New Instructional Approaches to In-Class Activity Based Learning.* Retrieved June 1, 2012, from YouTube: http://youtu.be/mwY9WZS-Sng

Strayer, J. (2007). *The Effects of the Classroom Flip on the Learning Environment: A Comparison of Learning Activity in a Traditional Classroom and a Flip Classroom that Used an Intelligent Tutoring System.* Educational Theory and Practice. Columbus, Ohio: Ohio State University.

Waguespack, L. (2008). *The Tinkertoy™ Exercise for Motivating Formal System Modeling.* Information Systems Education Journal, 6 (46), pp. 3-9.

Editor's Note:

This paper was selected for inclusion in the journal as a ISECON 2012 Meritorious Paper. The acceptance rate is typically 15% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2012.

Appendix I

Sample In-Class Activity (Creating Charts)

Work together in small groups to complete this assignment. Take turns being the reader, doer, and checker. The reader reads an instruction aloud while the doer completes it in Excel. The checker helps the doer if the doer needs help and confirm that each step is completed correctly. Help each other out, look up how to do things in the book if you're not sure, and if you're still stuck, ask me!

1. Visit http://data.worldbank.org/. Navigate to Data, then Indicators and explore the data sets that are available.
2. Select a data set of interest that has at least 5 years' worth of values. For example:
    - Mobile phone subscriptions per 100 people
    - Internet usage
    - Vehicles per km/road
3. Download the data. Import it into Excel.
4. Create a worksheet named Group Members. Include the names of the members of your group.
5. Examine your data. If there are a lot of empty columns from early years, hide or delete them. Keep at least 10 years' worth of data.
6. Create spark lines for the data. Add spark line markers.
7. Filter the data to display only those countries that begin with the letter A.
8. Create a new sheet named "A countries."
9. Copy row 1 (the header row), and the all of the rows for all of the countries that begin with A to a new sheet.
10. Create a line chart showing all of the data on one graph, where each line is a different country.
    - Label the horizontal and vertical axes
    - The legend should go at the bottom
    - The legend labels should be the country abbreviations
    - Horizontal axis should show the years
    - Your graph should have a title
    - Find a thematically appropriate image for the background of your chart
    - Place the chart on its own worksheet
11. Change the filter to display another subset of the data that you choose.
12. Copy the header row and all of the data to a new sheet.
13. Create a bar chart for the last 4 years of available data. Add appropriate labels, legends, titles, and formatting styles to your chart. Place the chart on its own worksheet.
14. Place the file in a Dropbox folder shared with the members of your group so that each group member will have access to this file on their own computers. Each group member should submit the (same) file to Blackboard to get credit for completing this assignment.

Endnotes

[i] Khan Academy hosts over 2600 instructional videos at http://khanacademy.org.
[ii] Most student tutors used Screencast-o-matic.com (http://screencast-o-matic.com) to create their screencasts, and then edited their videos using Windows Live Movie Maker. Screenr (http://screenr.com) , GoView (http://goview.com) , and Jing (http://www.techsmith.com/jing.html) are also popular free tools for creating screencasts.
[iii]To view the instructional videos that student tutors created for this project, visit http://cis.bentley.edu/sandbox/index.php/resources/excel/
[iv] Join.Me (http://join.me) is a free screen sharing application.
[v] Waguespack (2008) describes the roles of guide, builder, and judge that students take on during in-class modeling experiments. He pointed out the similarities with the roles of reader, doer, and checker introduced here for completing small group exercises.
[vi] Dropbox (http://dropbox.com) is a free cloud storage application that allows users to synchronize and share files across multiple devices.
[vii] Open data refers to data sets available for reuse without copyright restriction. For example, the US Government set up http://data.gov in 2009 as a way to share government data and provide transparency. Several cities, states, and countries have followed suit with similar open data sites.
[viii] Providing Data as a Service is a growing industry as companies such as http://factual.com, http://infochimps.com, and http://datamarket.com manage and provide large data sets as raw data or via APIs for developers to include in mobile and web applications. Some data is also available for download in CSV or other formats that Excel can recognize and import.
[ix] http://data.worldbank.org/indicator/SH.DYN.AIDS.ZS

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