Developing a Learning Tool for IT Education

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ABSTRACT
In this paper, the design science methodology is used to develop and evaluate a learning tool for use in a student centered, collaborative learning environment. The particular learning environment used in the study involves first year programming students in a tertiary environment and consideration is given to the special needs they have in learning a technically challenging and constantly evolving topic. A range of issues facing educators and learners is explored and from this the key requirements of a supportive learning tool are identified. This is used as the basis for developing a learning tool which is then evaluated using a combination of quantitative and qualitative methods. The tool used in this investigation was based on an adaptation of the Microsoft OneNote© application. It was found to be generally supportive in the chosen environment but further research would be required to determine if the results were transferable to other learning environments.

Categories and Subject Descriptors
K.3.1 [**Computers and Education]**: Computer Uses in Education – *collaborative learning, computer-assisted instruction (CAI), computer-managed instruction (CMI).*

General Terms
Documentation, Performance, Design, Reliability, Human Factors.

Keywords
Learning and Teaching, e-learning, Design Science, Artifact based research, Student centered learning, Interactive learning tools, Microsoft OneNote©

1. INTRODUCTION
Education, like information technology, has seen many changes in my lifetime. The teacher-centric primarily one way flow of information has changed to a student-centric two way flow of information. Currently, education is undergoing a further transformation to a student-centric discovery of information. This change has been prompted not only by the development of our understanding of the process of learning, but also by the recognition of the needs of the workplace for employees who are lifelong learners with "adaptive expertise" [3]. Historically, experts were specialists in their field and any new work built on their body of knowledge. Bransford suggests that technology is changing so fast that experts need to be able to adapt, not just specialise, and that this is a skill we as educators need to impart to our students. No longer can the educator be the font of all knowledge, the student has to learn to discover for themselves their own path to learning. While Bransford's work focussed on the Engineering environment and its rapidly changing technology, his findings are equally valid in the IT sector which also faces continuous development of technologies [3].

This new style of learning is a challenge for both educators and students. There is a certain comfort in leaving a lecture with a wad of carefully copied notes. In their work on student centred learning, Lopez and colleagues agree that student centred learning empowers students and enables them to achieve but caution that "Students may be uncomfortable with practice that is not aligned with their expectations and may worry that they will not achieve their learning objectives adequately" [10]. So while research shows that this new style of teaching encourages self-learning and teaches a new skillset which Bransford suggested is needed in a technological environment, this may not have the support of the student (or possibly even the educator).

This research seeks to identify a tool to reduce the challenges facing learners and educators who adopt this style of learning. It will also consider the challenges introduced by environmental factors such as increased class sizes, increased teaching load for educators and reduced contact time per subject. It will look at the changes students face as learning moves from textbooks and lecture halls to student supplied resources (BYOD's) and open space environments.

As a learning tool is to be produced and assessed, a Design Science approach has been selected. This provides a structured iterative process well suited to developing and evaluating an andragogical artefact. Hevner and associates note: "The result of design-science research in IS is, by definition, a purposeful IT artefact created to address an important organizational problem." [7]. It allows for a pragmatic combination of qualitative and quantitative evaluation of the learning tool with a problem centric approach. Offerman and co-authors explain: "The process combines qualitative and quantitative research and references well-known research methods" [11].

The rest of this paper is structured according to the design science methodology [4] of:

- problem identification and motivation
- definition of objectives of a solution
- design and development of an artefact
- demonstration of the artefact
- evaluation of the artefact
- communication of the results

2. PROBLEM IDENTIFICATION
As discussed in the introduction, both the way we teach and the graduate capability requirements of our students are changing. In addition to this, there is constant pressure to do more with less

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particularly as performance (as measured by pass rates) is now a key funding metric. Some institutions are removing lab based computers in favour of student supplied technology (often called Bring Your Own Device or BYOD), are eliminating text books and are altering the dynamics of the classroom to reinforce the shift from teacher-focused to student-focused andragogies.

Students are also driving their own changes, with texting, Twitter and Facebook the communication tools of choice. Students can create, join, leave and re-join collaborations at will. They expect instant (synchronous) communication and instant feedback but show a preference for communication with their lecturers to be separate to their peer networks and to some extent to be asynchronous [2].

The tools we have traditionally used to support learning were developed with a lecturer-focused learning approach and as technologies developed these traditional tools were adapted to the new technologies. For example we have seen the progression from blackboard to overhead projector to PowerPoint display without necessitating a real change in andragogy. Even advanced tools such as Blackboard (the course management tool) are used by many as an organisational and document management tool rather than an instructional tool [16].

The challenge for educators therefore is threefold; to meet the demands of the current teaching environment; to create a supportive and collaborative learning environment; and to meet the students' expectations of synchronous communication.

3. OBJECTIVES OF A SOLUTION

While the identified problem does not necessarily require a technological solution, it is the intent of this paper to identify, develop and evaluate a technological tool for this purpose. As such, it is important to define the key elements of an ideal solution. This can then be used not only in the selection and development of the learning tool but also in the evaluation process as a measure of the success of the artefact.

3.1 Demands of the current teaching environment

Prior to the commencement of this study, several focus groups of IT lecturers were asked to consider the requirements of an ideal learning tool. These were convenience samples containing specialists in the IT education sector. Although these focus groups cannot be considered a representative sample, they contain the collective expertise of many years in the IT education sector. Thus, the findings they produce provide a strong starting point for defining the objectives of our solution. Their initial findings were summarised into a list of key requirements and this list was then rated under the categories 'required', 'preferred' and 'optional'. Table 1 summarises these findings.

Table 1: Focus group results

Requirement	Required	Preferred	Optional
Device Independent, supporting tablets and smartphones as well as the more traditional laptops and pc's.	**X**		
Accessible anywhere/anytime	**X**		
Fully interactive, integrating seamlessly with Smartboards and other interactive tools	**X**		
Supports group work	**X**		
Quick and easy to navigate between resources	**X**		
Supports student centered learning	**X**		
Support a changing environment	**X**		
Provides a resource center for students	**X**		
Adaptable to student and lecturer needs	**X**		
Andragogically flexible	**X**		
Supports online testing		**X**	
Affordable or free		**X**	
Empowers students and lecturers		**X**	
Low learning curve		**X**	
Supports multiple types of files		**X**	
Avoids excessive validation (such as multiple login requirements)		**X**	
Instantly updates as work developed		**X**	
Private and secure			**X**
Highly customisable			**X**

Students are increasingly using BYOD devices. These incorporate the full gamut from smartphone to high end laptops. While some specialist papers would require a minimum standard (including entry level programing papers), these are in the minority. A learning tool will need to be adaptable to all devices. Microsoft's white paper on BYOD devices in education [5] reflects on the capabilities of each device. It determines that many devices such as tablets and smartphones are best suited to the consumption of information rather than the production and care should be taken to ensure students have a device suitable to their needs. This runs contra to the focus group beliefs listed above where a key requirement for a learning tool is to be fully device independent.

While there may be some standards imposed, clearly any learning tool must be device and operating system independent. In addition to this, simply equipping students with their own devices and digitising existing curriculum is not the right approach. The challenge for any BYOD incorporation is to create "confident, flexible, self-directed, lifelong learners" [5].

3.2 Needs of a supportive collaborative learning environment

One of the main IT streams to be supported is the programing stream. Evidence suggests introductory programing presents

particular learning challenges, but how does this affect our learning tool design? Literature suggests that for entry level students "an average student does not usually make much progress in an introductory programming course" [1]. It also notes that there are typically two types of students, "students who learn without excessive effort and those who do not learn without inordinate personal attention" [1].

Robins has an explanation for this bimodal outcome for programing students. He suggests a new model for student learning (described as the 'learning edge momentum model'), where learning objectives are interrelated and failure to understand one element impacts negatively on the ability to comprehend another. This results in failure rates of up to 60%, particularly as class sizes increase [13]. One suggested solution to this problem is through collaborative work on projects relevant to the student [3].

It is useful then to describe the key elements of a collaborative style. Based on Scheuermann's work [14], these are:

1. activities that are learner centred
2. instruction that is personalised
3. learner experiences that are solicited and linked to the learning
4. student needs that are assessed
5. educational climates that are developed where making mistakes and taking risks is normal
6. learning processes where the learners play an integral role
7. opportunities for personal development that are flexible

Clearly, there is an opportunity for technology to support collaborative learning but many of the objectives identified above could be accomplished without any technological support. IT education is perhaps unique in the sense that many of its subjects could not be taught in the absence of computers and there is an expectation that IT students can adapt readily to new technologies. The temptation then is to adapt all teaching to utilise available computing tools, but this is not necessarily desirable. Indeed some argue it is better to use "seamless movement into the use of the computer to complete an activity or lesson *only when the technology would truly augment learning*" [16, p.12].

3.3 Students Expectations

Existing research suggests that digitally-minded students want information fast but they want it presented visually and interactively [2]. They choose to engage in synchronous interactive activities among their social network. However, this does not necessarily translate to a learning environment where artificial communities are established. To achieve truly collaborative groupings requires cohesion, trust, respect and a sense of belonging. Simply providing an environment where collaboration can occur does not mean it will occur [9].

4. DESIGN AND DEVELOPMENT

The objectives can be grouped into 7 distinct requirements (Table 2).

Table 2: Requirements

Supports multiple simultaneous users for both synchronous and asynchronous use
Easily accessible and readily available
Customisable to the needs of the user
Provides for resource storage and retrieval
Works with interactive tools such as SmartBoards
Integrates seamlessly into the lesson
Quick and easy to both use and to learn to use

4.1 Existing Tools

Currently employed learning tools (such as Blackboard© and Moodle©) meet some but not all of these needs and are constrained in their design. Ray Henderson, president of teaching and learning at Blackboard, agrees that we "are facing a sudden change in the landscape of student use of computing devices" which requires "a bold, imaginative approach" not possible through adaptation of existing products [6]. While Blackboard and others are looking to develop new, more flexible products, at the time of development of the teaching tool these were not available for consideration.

Google Docs, Office 365 and similar online systems can be adapted for use as a learning tool and offer excellent synchronous and asynchronous collaborative opportunities. They meet most of the requirements given, are affordable, customisable and easy to use. As these are a third party online service, server and firewall issues prevented these being considered for this study. While it is acknowledged that these issues can be overcome, it would require an attitudinal shift in some quarters and raised compliance concerns beyond the ability of the researcher to influence.

Social networking tools such as Facebook, blog sites and even YouTube© can also being adapted for andragogical purposes. These were not selected for this study due to major privacy concerns with this particular media [15].

4.2 An alternative tool – Microsoft OneNote©

One tool which appears to meet most of the requirements is Microsoft's OneNote©.

First, it supports multiple simultaneous users for both synchronous and asynchronous use. It has a database engine behind it, allowing multiple users to access resources simultaneously. If students have read/write access to a common file store they can work simultaneously on the one document either co-authoring one page or each working on a separate page to produce a combined output.

Second, it is easily accessible and readily available. Students have access to the web version of this product as part of their student email suite and free OneNote apps have become available for I-devices and Android. In addition to this, the Dreamspark STEM subscription allows students to download the full version free for study purposes giving them the ability to use OneNote on multiple devices and any location and files stored on network drives can be accessed without any additional authentication. Native format documents are stored in an 'open' state, moving between them is simple and quick with no delays while a document loads.

Third, it is customisable to the needs of the user. Each user can customise their own notebooks and add pages from a common source as needed.

Fourth, it provides for resource storage and retrieval. In addition to its native pages, it can provide either a storage receptacle or a link to any type of file. It does not provide readers for these files, the relevant application software must be loaded.

Fifth, it works with interactive tools such as SmartBoards©. It has a range of built in interactive tools which adapts to multiple input devices such as SmartBoards© or tablets. It does not support the use of an iPad© for this purpose.

Sixth, it may be integrated seamlessly into the lesson. However, this can only be established through a live study.

Finally, it is expected to be quick and easy both to use and to learn to use. However, again, this can only be established through a live study.

4.3 Development of the tool

There is little information available on the use of this product in a learning environment. Therefore it is necessary to develop andragogical methods before assessing the tool from both a learner and a lecturer perspective.

OneNote documents (note books) were created containing all course materials. Daily lecture plans became live documents which were edited during delivery. Students accessed the edited documents during class time to facilitate their independent learning, providing a base for their explorations of the topics.

Notifications and links to reference material for assessments were embedded in the documents. There was no facility for integrated testing however links to testing facilities could be provided.

Implementation was hampered by technological issues. Without an SSL internet connection, it was not possible to share database information over the internet. This prevented the students from accessing the OneNote files remotely and restricted use of the range of free OneNote tools for web, iPad© and Android©. OneNote group projects relied upon access to a shared read/write LAN location. Unfortunately this could not be accommodated under the current network server system and required changes could not occur in the time frame of this investigation.

Access to SmartBoard© equipped rooms was limited with only some of the subjects included in this evaluation having access to these rooms. Interactivity with the artefact during lectures was constrained as a result, although it is recognised that the potential for such interactivity exists in the artefact.

5. DEMONSTRATION

A purposive selection was made of all first year programming students at the participating institution. This enabled the researcher to capture the impact of the learning tool on a variety of subjects but with a focus on the key area of introductory programming [8].

The tool was integrated into the daily lesson plan and contained all required background materials with links to external information sources. It also included coding snippets by subject (eg how to write an IF statement). The tool provided various scenarios and objectives for lessons as the basis for collaborative exercises.

Students could look to the relevant note book to find lesson plans, upcoming assessment information, resources to support their current activities and general tips, links and resources to help them with their studies. They could incorporate this information into their own notebook, stored either on their network drive (with remote access) or on a portable storage device.

In keeping with the iterative nature of a design science approach [4], at the end of the semester a self-selected group of students and lecturer reviewed the effectiveness of OneNote as a learning tool with an aim of refining its use. This group identified a student requirement previously missing from the evaluation – video tutorials and teaching tools. While OneNote itself only has limited video recording facilities, video files can be inserted into documents at will.

With the incorporation of these video files and with other minor refinements, a revised version of the tool was introduced the following semester.

6. EVALUATION

Towards the end of the semester, the artefact was evaluated from both a lecturer and a student perspective. The student perspective was captured with a questionnaire. Questions were geared towards the identified requirements including the new requirement of video. Responses were on a standard five point Likert scale. These responses were aggregated to positive, negative and neutral in the final evaluation. All students were invited to participate but participation was optional and anonymous.

The lecturer evaluation is based on personal reflection of the performance against the criteria from an andragogical and technological perspective. As there was only one lecturer involved in the study, it is not possible to remove personal biases from this evaluation and the lecturer concerned is a proponent of the use of OneNote for a variety of purposes.

6.1 Student perspective

Table 3 summarises the results of the student questionnaire.

Table 3: Student Perspective

Student Assessment of Learning Tool (% partially agree or strongly agree, N=76)	
Provides for resource storage and retrieval	97%
Quick and easy to both use and to learn to use	97%
Integrates seamlessly into the lesson	93%
Supports multiple simultaneous users for both synchronous and asynchronous use	92%
Customisable to the needs of the user	89%
Easily accessible and readily available	86%
Provides support for video tutorials	81%
Works with interactive tools such as SmartBoards©	79%

Note: not all respondents answered every question

6.2 Lecturer perspective

Overall the lecturer noted a high level of engagement and was generally positive about the use of the tool. With regards the requirements, the following summarise the lecturer's view.

6.2.1 Provides for resource storage and retrieval

The lecturer was able to place all material needed for a lesson in the relevant weekly lesson tab. Material common to several courses could easily be copied between notebooks. Students regularly referred to notes, particularly for programming

assistance and reinforcement of basic principles. Links to online material could be incorporated into the lesson notes and the lecturer noted "material inserted from the web automatically contained a link to the source website, allowing students to explore a topic further"

Students who missed lectures were able to use the OneNote documents to revise missed work. It enabled students to repeat and revise complex concepts at will in a readily accessible format. Programming snippets could be broken down by topic and drawing tools allowed logic paths to be expressed visually.

6.2.2 Quick and easy to use

Very little instruction was given to students; the basic features were intuitive and provided no challenge to the students concerned. The lecturer felt however that less technically literate students would most likely require some tuition.

Some of the more advanced features were not fully explored or used, and some features such as integration with outlook were not available to students.

6.2.3 Integration into the lesson

With the opening of the OneNote application, the relevant notebooks opened automatically. Relevant lesson material was immediately available to the student, and previous lesson material was easily and quickly available.

Students working on programing exercises could easily access coding information such as the basic structure of a 'for' loop. This allowed students to focus their attention on design of the program, "This enabled students to spend more time thinking about how to problem solve".

It was noted students used OneNote to check for upcoming assignments and tests, took copies of crucial pages for use outside of class and added and edited their own versions of the notes.

6.2.4 Synchronous and asynchronous use

The dynamic nature of the tool allowed changes to be made in class, to further illustrate a point or to expand in a student driven direction.

Where students required a copy of some workings, a simple copy and paste from the IDE allowed students immediate access to the code.

The lecturer's biggest regret with this trial was that OneNote's use as a synchronous collaborative learning tool was not able to be explored. As there was no student access to a shared read/write LAN location this feature was not available internally. External cloud based options encountered firewall issues, so while the potential is there it could not be utilised or evaluated.

6.2.5 Customisability

The lecturer adapted the tool to the requirements of each class. Students copied supplied pages into their own Notebooks (OneNote's term for a collection of pages and sections) which they could customise to their own preference.

Not all students took advantage of this feature; quite a few simply used the Notebooks as provided. This was seen as a positive by the lecturer as students who had no interest in customising the work were not forced to do so.

6.2.6 Accessibility and availability

The ability to access information off campus was limited to asynchronous data and required authentication, but on campus it was readily available with no authentication required. The lecturer found the ability to move between pages without having to wait for an application to load a file a significant positive. However the inability of students to access a communal read/write location was seen as a significant negative.

6.2.7 Incorporation of video elements

The use of embedded video explaining key elements was particularly effective. This was simple to incorporate into the OneNote pages as video icons and clips ran directly from the icons. The recording feature built into OneNote would record from a camera, but was not capable of screen capture. Some students used this for recording in class, but for resource purposes, recording had to be made using third party software and then inserted into the pages. This was a time consuming process and only a small number of videos were created.

6.2.8 Use with interactive tools

The drawing tools provided with OneNote generally worked well with the interactive projectors provided, allowing dynamic code exploration and seamless capture of the results.

There were occasions when pen work would appear "blobby" and "dribbles" would appear on the pages. This created enough frustration that there was a general overall dissatisfaction.

The use of tablets was explored as well, but this was found to disengage the students as the focus of the lecturer was on the tablet not on interactions with the students.

7. CONCLUSION

While no tool is capable of meeting every need, in this study OneNote has proven to be a versatile, adaptive and easy to learn addition to the tertiary learning environment. It was readily accepted by student and educator, meeting most of the identified requirements.

Its strengths are its ease of use and its resource management features. It supports interactivity, but not seamlessly and while it supports video files, it is not suitable as a video production tool.

Caution must be shown however as the findings in this report are based on technically literate students and a single lecturer familiar with the OneNote product. It would require further trials with a greater range of students and lecturers to establish if the generally positive results are transferable into other learning sectors.

While it was disappointing not to be able to utilise the synchronised collaborative learning features, this is something which could be explored in the future.

Finally, it is worth noting that OneNote is a bespoke storage, organisation, dissemination and collaboration tool. Its value as a learning tool is very much dependent on the resources provided and the design of each individual delivery structure. It is therefore a requirement to have a thorough understanding of the use of e-learning tools to capitalise on the benefits it offers. Unfortunately, as Reeve and Flowers [12] note in their study of e-learning in the UK, while significant staff development should occur, it rarely does. Without a commitment to knowledge and teaching development, OneNote risks being little more than a highly flexible file storage system.

REFERENCES

1 Ala-Mutka, K. Problems in learning and teaching programing., City, 2004.

2 Andone, D., Dron, J., Pemberton, L. and Boyne, C. E-learning environments for digitally-minded students. Journal of Interactive Learning Research, 18, 1 2007), 41-53.

3 Bransford, J. Preparing people for rapidly changing environments. *Journal of Engineering Education*, 96, 1 2007), 1-3.

4 Cleven, A., Gubler, P. and Huner, K. Design Alternatives for the Evaluation of Design Science Research Artefacts. In Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology (2009). ACM.

5 Dixon, B. and Tierney, S. Bring your own device to school. Microsoft Corporation, www.microsoft.com, 2012.

6 Henderson, R. Blackboard, 2010.

7 Hevner, A., March, S., Park, J. and Ram, S. Design Science Paradigm. MIS Quarterly Executive, 28, 1 (March 2004), 75 - 105.

8 Higginbottom, G. Sampling issues in qualitative research. Nurse Researcher, 12, 1 2004), 7-19.

9 Kreijns, K., Kirschner, P. and Jochems, W. Identifying the pitfalls for social interaction in computer-supported collaborative learning environments. Computers in Human Behaviour, 19, 3 (May 2003), 335 - 353.

10 Lopez, M., Lopez, D. and Simpson. Explore, Discover, Share, Discuss: A student centred approach to learning. In Proceedings of the CITRENZ Conference (Christchurch, New Zealand., 2012).

11 Offerman, P., Levina, O., Schonher, M. and Bub, U. Outline of a design science research process. In Proceedings of the Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology (Philadelphia, 2009). ACM.

12 Reeve, S. and Flowers, S. The shape of things to come, a discussion on the nature of the technologised higher education institution. In Proceedings of the 10th annual CTI-AFM Conference (1999). CTI Center for Accounting Finance and Management

13 Robins, A. Learning edge momentum:A new account of outcomes in CS1. Computer Science Education, 20, 1 (March 2010), 37–71.

14 Scheuermann, M. Perceptions of nontraditional students and their instructors regarding the collaborative teaching and learning mode and the socialized expectations students bring from the workplace into the undergraduate classroom. Drexel University, 2005.

15 Stutzman, F. Facebook as a Tool for Learning Engagement, 2006.

16 Wilson, J. The Blackboard Jungle: A case study of instructor and student perceptions of the learning technology tool Blackboard. Wichita State University, Wichita, 2007.