As part of National Institute of Education (NIE) Library’s LIBRIS strategic master plan to transform the Library, NIE Library seized the opportunity to engage users by providing value-adding Library services through the implementation of a makerspace in 2014. This paper aims to share National Institute of Education (NIE) Library’s experience and learning points in the implementation of the makerspace.

With increasing interest in makerspaces and its potential in Libraries, a number of Libraries have been exploring the introduction of makerspace within library premises. NIE Library launched the makerspace in 2014 with the aim to provide an avenue to encourage NIE community to:

- Embrace the spirit of experimentation, innovation and creativity.
- Learn how emerging technologies can bring their creation to life.

The makerspace is equipped with a 3D printer that allows users to perform rapid prototyping of their design ideas and projects. Besides the ability to print professional quality 3D artefacts, the 3D printer is also environmentally friendly as the filament used for printing 3D
objects is a form of renewable bioplastic (polylactic acid or PLA) derived from plants. Ever since the makerspace was launched in 2014, NIE Library has seen huge interest from the NIE community and visitors.

This paper will share NIE’s experience in the implementation of makerspace. In particular, the observations, impacts, challenges, benefits and learning points of having makerspace in the Library are examined for discussion, further exploration and future developments.

**Keywords:** Makerspace, Collaborative Space, 3D Printer, Library Services

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### Introduction

As part of National Institute of Education (NIE) Library’s LIBRIS™ strategic master plan to transform the Library, several innovative information services and projects were identified as strategic initiatives to enhance users’ experience with the Library (Wan-Yeoh, 2010). One of the key strategic initiatives was the Library as Space project. The project aimed to elevate the Library from a place to a space, incorporating service space, collaborative space and knowledge space.

Within a variety of spaces to meet the changing needs of library users, one huge emphasis of the Library as Space project was to provide space that allows patrons to collaborate, brainstorm and create knowledge, rather than merely to consume information. The collaborative space was designed to serve this purpose and also to provide opportunities for library users to gather, collaborate and socialize while learning new skills and creating new knowledge.

One of the key ideas that emerged as part of the design of the new collaborative space is the makerspace. Makerspace (also referred to as hackerspace) can be defined as ‘a place where people come together to create and collaborate, to share resources, knowledge and stuff (Britton, 2012). Key characteristics of makerspace, such as collaborating, sharing, creating and learning therefore fit into NIE Library’s vision for the collaborative space.

In early 2014, a project team was set up to look into implementing makerspace as part of collaborative space. The following sections will share NIE’s experience in the implementation of makerspace, including the observations, impacts, challenges, benefits, and learning points of having makerspace in the Library.

### Literature Review

Makerspaces can be broadly defined as community-oriented spaces where people gather to create, make and learn using 3D printers and a variety of tools (Kelly, 2013). A review of the literature surrounding makerspaces and libraries showed that they are avenues for good synergy to be derived by having makerspaces within libraries. Dale Dougherty, founder of Make magazine, described the maker movement as one that valued education and learning by young people (Dougherty, 2012). Such principles are very much aligned to library’s mission; thus, makerspaces can be seen as a natural fit with the aims and mission of NIE Library.

While libraries and makerspaces can exist and work separately as they frequently do, the services can also be blended together to create an enhanced library service (Bilandzic, 2013; Kalish, 2011). The intersection potential between
makerspaces and libraries is high and the divide between libraries and makerspaces is deemed as shrinking (Bagley, 2012). At the same time, more makerspaces equipped with 3D printing facilities were being introduced in Singapore’s Secondary Schools (Tan, 2014). One likely reason for these phenomena was to use makerspace as a conduit to complement efforts that encourage participatory learning (Hamilton, 2012). As NIE Library’s main group of patrons are the student teachers, it makes for a lot of sense to have a makerspace within NIE Library given that the schools in Singapore have begun setting up makerspaces.

The key purposes of having makerspaces in Libraries include the demand to expand library services through increased technology offerings, spaces and activities (Blowers, 2012), to foster community engagement, involvement and participation, and to transform traditional understandings of libraries as places of information consumption to places of knowledge creation (Ginsberg, 2012).

One of the most common benefits derived from having makerspaces in the libraries is the effectiveness of makerspaces in garnering interests and engaging users (Slater & Howard, 2013). On the flip side, the key challenges experienced by libraries who attempted to implement makerspaces include the resistance to the novel idea and the budget constraints in setting up makerspaces (Greenwalt, 2013). While NIE Library faced similar challenges, the benefits from implementing the makerspace far exceeded the expectations of the project team. Subsequent sections shall provide details on how the project benefitted NIE Library.

**Background**

Founded in 1950 as a Teachers' Training College library, the NIE Library and Information Services Centre is the largest education library in Singapore. It provides resources to support the teaching, learning and research programmes of the Institute. The NIE Library also reaches out to education professionals in the Ministry of Education, schools and other related organizations.

NIE Library occupies 4770 m$^2$ of space across three levels (level 2 to level 4) in a building. Witnessing the paradigm shift from supporting print collection to electronic resources, the Library contemplated optimizing physical spaces to support the changing needs of her patrons. The Library as Space project, a key initiative under the LIBRIS$^{21}$ strategic master plan was to elevate the Library from a place to a space, was conceptualized with the intention to optimize the space, rationalize the services and value add to the overall mission of NIE.

The project consolidated three service counters located at three different locations within the Library, namely circulation, reference and media counters into a single service point at level 2. The single service point was aptly named as service space. The move not only optimizes library space, but also makes it easy for users to engage with library services as a one-stop service counter for all kind of library enquiries.

Besides service space, the Library as Space project further incorporated two major spaces, the Knowledge space at level 4, a space with the main bulk of NIE Library’s print resources and the collaborative space, a space that allows patrons to collaborate, brainstorm and create knowledge, rather than just consuming information.

**Collaborative Space**

The collaborative space is one of the major highlights of the Library as Space project.
The collaborative space was envisioned to be a space where NIE community gathers, collaborates, brainstorms, socializes while learning new skills and creating new knowledge. To implement this vision, the Library as Space project team worked with interior designers to reconfigure the space at level 3 of the NIE Library.

Physical shelf spaces were repurposed to make way for PODs, which are small discussion rooms equipped with digital TVs, meeting tables and chairs as well as writing surfaces on the wall. The PODs are popular among users for discussion, mock presentation and knowledge sharing. The Media service counter and its adjacent space was consolidated as part of collaborative space. The space freed up was repurposed to increase the sitting space equipped with comfortable furniture that are conducive for small group discussion. Overall, the Library as Space project resulted in an increase of 22% in sitting capacity, with the majority of the contribution coming from the collaborative space.

Makerspace

Incidentally, NIE Library’s makerspace, which has become the jewel in the crown within the collaborative space, was a result of an innovative idea that emerged from the collaboration and discussion with Translation and Development Unit (TDU), another unit within NIE that serves to translate NIE research and introduce them to the schools in Singapore.

The Makerspace aspires to build a community where members share and collaborate to bring ideas to fruition. To this end, the Makerspace is equipped with a 3D printer for users to rapidly prototype their ideas. A printed sample allows them to evaluate aspects such as aesthetics and ergonomics. Two DIY projects have been made available for users to build their own bristle bot and rubber band aircraft and learn about electronics and aerodynamics experientially. These will perhaps inspire them to incorporate electrical and mechanical parts in their designs. There are plans to showcase projects similar to those being done in schools so that our student teachers are kept updated. Currently, TDU is working with seven secondary schools in creating Makerspace in schools as well as exploring the use of 3D modelling and printing as part of the design process in the lower secondary Design and Technology curriculum.

The dynamic and competitive landscape demanded that the education system produces students equipped with higher order thinking skills, rather than just remembering facts (rote learning). As reflected in the revised Bloom’s Taxonomy, higher order thinking skills include analysis, evaluation and creation in the taxonomy for teaching, learning, and assessment (Anderson & Krathwohl, 2001). Responding to this shift in focus, there are attempts to refine the education policies to one that put more focus on constructionism and invention instead of instruction and industrial methods.

![Figure 1. Bloom’s Taxonomy illustrated here as a pyramid hierarchy to show that learning at the higher levels is dependent on having attained prerequisite knowledge and skills at lower levels. Reprinted from Using Bloom’s Taxonomy to Write Effective Learning Objectives, In Teaching Innovation & Pedagogical Support, by J. Shabatura, 2013, Retrieved August 28, 2015,](image-url)
Makerspace provides a great opportunity for users to practice these higher order thinking skills. By providing a space where learners come together to share, tinker, experiment, prototype and create, learners take command of their own learning and collaborate to create new solutions and knowledge, instead of merely consuming information.

When the idea of having makerspace was mooted in the collaborative space, TDU had begun working with secondary schools in Singapore to introduce 3D printing as part of curriculum in Design and Technology course. This made it all the more worthwhile to have a makerspace in NIE so that the student teachers, who are NIE’s main group of students, are exposed to these technology before they begin their teaching career in schools.

**Equipments in Makerspace**

The makerspace in NIE Library is equipped with a 3D printer that allows users to perform rapid prototyping of their design ideas and projects. The model of the 3D printer NIE acquired is the MakerBot Replicator 2 Desktop 3D printer. The 3D printer uses additive manufacturing technique where 3D objects are built from digital 3D models by slicing them and layering materials on top of the slices to form 3D artefacts. This is achieved by depositing plastic in the melt state which solidifies upon cooling.

The additive manufacturing process has many advantages over the traditional subtractive manufacturing process such as those used by Computer Numerical Controlled (CNC) milling machines. In the subtractive manufacturing process, 3D artefacts are created by having the milling cutter removing material from the surface of a work piece. The advantages of the additive manufacturing process over subtractive manufacturing process include tool-less fabrication, low cost rapid prototyping, and an ability to produce parts with increased design complexity (Pham and Gault, 1998; Wendel et al., 2008; Berman, 2012).

In addition to acquiring 3D printer, the project team also added a dedicated PC station that is installed with the Google SketchUp and MakerBot 3D printing software. The Google SketchUp software is a 3D modeling software that enables users to easily draw 3D objects. The 3D objects drawn can be exported as digital files and sent to the MakerBot 3D printing software for printing.

For users who are hesitant to invest time in learning Google SketchUp, MakerBot created a website known as Thingiverse. Thingiverse is a website dedicated for the 3D printing and design community to discover, print and share free 3D printing models. Users can easily download ready-made 3D objects digital files from Thingiverse and print the 3D objects. In some instances, users can also download the 3D object’s source files from Thingiverse and make amendments to the designs using 3D modeling software like Google SketchUp.

Besides the ability to print professional quality 3D artefacts, the 3D printer is also environmentally friendly as the filament used for printing 3D objects is a form of renewable bioplastic (polylactic acid or
PLA) derived from plants. With the increasing adoption of 3D printing, the costs of PLA filament have become more affordable due to economies of scale. In order to encourage usage and adopt 3D printing, the NIE Library absorbs the costs of the filament and offers free 3D printing service to her users.

**Community Engagement**

Based on past experiences with launching new library services, the project team understood that having the equipment to print 3D artefacts would not be sufficient to generate substantial engagement. In order to generate interests, the project team designed attractive posters that carefully explained how 3D printing works, giving additional information on the history of 3D printing and how one can easily print 3D artefacts in simple steps. The posters are prominently displayed at the makerspace to raise awareness of the new library service.

Besides having attractive posters, the project team also showcased some of the more interesting 3D artefacts that are printed using the 3D printer. The 3D objects displayed include 3D containers that are waterproof, artefacts that have parts printed in different colors and assembled as whole, 3D objects with curvatures and, items that are printed as a whole with movable parts. The display of these unique 3D objects illustrates the possibility of prototyping designs using 3D printers and inspires patrons to try hands on with 3D printing.

The NIE Library announced the new library service through multiple marketing channel such as emails, announcements on portals and publishing articles in blog posts and newsletters (Library and Information Services Centre, 2014). The project team also provided demonstrations to library staff on the use of 3D printers. Amazed by the possibility of 3D printing, several library staff have been active experimenters of the makerspace. These staff served as ambassadors for the makerspace; not only do they show users how to print 3D objects using 3D printers, they also spread the availability of the new library service by word-of-mouth. Raising awareness by word-of-mouth has been one of the most effective means as the Library has established strong relationship with many library supporters through the years.

Since the initial launch of the makerspace, NIE Library witnessed tremendous interests on the use of 3D printers. Various design projects were prototyped using the 3D printer. The objects included 3D teaching aids, new designs for musical instruments and rapid prototyping of sports equipment, to name a few. The project team observed that as users got more sophisticated, there was pent-up demand for more complex design. To address the demand from these sophisticated users, NIE Library collaborated with TDU and an industry partner to conduct workshops that taught participants how to design 3D models using Google SketchUp.

NIE Library has also been an active experimenter of makerspace. For instance, NIE Library printed 3D bookmarks using the 3D printers. These bookmarks served as souvenirs and were distributed during library tours, instructional classes, NIE open houses and library promotion events. In another instance, when 3D letters at the Gallery were damaged, NIE Library made use of 3D printers to print out 3D letters as replacement. This resulted in a 90% cost

![Figure 3: Samples of 3D artefacts displayed at the makerspace](image)
saving compared to having the letters replaced through commercial vendors.

**Benefits**

One of the most significant benefits of having the makerspace in NIE Library has been the level of interest that it garnered from the NIE community and especially visitors. In particular, the makerspace has become a focal point of all library visits. Several high ranking officers from ministries and other universities were extremely impressed by how NIE Library leveraged on technology to provide innovative Library services. These impressions not only raise the awareness of NIE Library as an innovative department but also promote NIE as a forward looking organization.

The makerspace has also become an effective channel for NIE Library to connect with her users; various collaborations that spun off from the makerspace, for example, collaborations with teaching staff on rapid prototyping of teaching aid, joint project with other units to provide 3D printing workshops, and various sharing sessions that provide demonstrations on the use of 3D printing.

Another key benefit of the makerspace is providing equitable opportunity for all her users to gain access and exposure to new technologies. Although 3D printing has become commercially viable, the novelty of the concept and the relative cost involved in owning one makes it impractical for individual students to own a 3D printer. By providing 3D printing facility, NIE community has equitable opportunity to access technology and explore the possibility of incorporating makerspace in their learning.

Moreover, many schools in Singapore are beginning to incorporate makerspace in design and technology curriculum. Having a makerspace in NIE Library makes sense as the makerspace gives opportunity for the student teachers to gain exposure to such technology prior to their teaching career in schools.

Finally, an accidental benefit derived from the makerspace project has been the change in mindset and the learning gained by library staff. While many were skeptical and hesitant on how makerspace can value add to library services, the implementation journey and subsequent success of the project provided valuable learning experiences for NIE Library. These are invaluable as the Library faces increasing demand to adapt to the dynamic information landscape and adopt innovative services to remain relevant.

**Challenges**

One of the main challenges faced was budget pressure amidst other priorities the NIE Library had planned for as part of LIBRIS21 project. Fortunately, Library’s management believed strongly in the value of makerspace and supported the idea. The project team also made adjustments to the initial plans so as to accommodate budget constraints. Instead of making a huge investment on expensive new furniture, display cabinets and equipment, the project team reused existing furniture, PCs and display cabinets to keep the budget low. The project team was also fortunate to partner with TDU, who through their contacts brought in a low-cost 3D printer, provided skill sets to set up, performed basic troubleshooting for the 3D printer, and finally sourcing for economical 3D printing filaments.

The second major challenge was the technical skills to support 3D printing facility and software. As the technology was very new, none of the library staff had experience and the technical know-how to implement such technology. This was
overcome by collaboration with TDU and
the industrial partners TDU introduced to
the Library; together, they not only taught
the core project team how to provide basic
support for 3D printing but also offered
technical workshop to train other NIE
users who were keen to explore
sophisticated techniques in 3D printing.

Lastly, there was significant challenge in
going get buy-in from project team members.
Many were skeptical about the makerspace
concept and its relevance in NIE Library.
As a very new concept, there were doubts
whether the service would be sustainable
in the long run. Despite these doubts, the
initial success and the interests garnered
quickly proved the sceptics wrong.
Overcoming these challenges further
inspired the team to adopt an open mindset
and take calculated risks in future projects.

Conclusion

The makerspace in NIE Library has been a
great success and exceeded the
expectations of both the project team and
the NIE community. While there are significant challenges in the project
implementation phase, the huge benefits
from the makerspace far outweigh
the efforts in overcoming these challenges.

Going forward, the project team will be
looking at ways to enhance the
makerspace. Several initiatives are being
explored, including adding 3D scanner,
working with NIE researchers on research
projects involving how makerspace
influence cognitive learning, and
conducting more advanced workshops by
collaborating with experts in the field of
3D printing.

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