Tan, S. C. et al. (Eds.) (2013). Workshop Proceedings of the 21st International Conference on Computers in Education. Indonesia: Asia-Pacific Society for Computers in Education

Mobile Supported Flipped Instruction and Learning

Wan NG
School of Education, University of New South Wales, Australia
*w.ng@unsw.edu.au

Abstract: The discussion of *flipped classroom*, while not an entirely new concept to the field of teaching, has been very active on blog sites on the Web in recent years while its academic literature to date is scant. This paper presents a review of the literature on the concept, discusses mobile-supported flipped classroom teaching and learning, presents an example of a mobile-supported flipped classroom pedagogy and identify benefits, issues and implications of flipped classroom.

Keywords: flipped learning and teaching, mobile technology, pedagogy

1. Introduction

The *Inverted Classroom* is a term first used by Lage, Platt and Treglia in 2000, which was later adopted in other studies (e.g. Talbert, 2011; Strayer, 2012) in the higher education contexts. Synonymous with the inverted classroom is the *Flipped Classroom*, usually referring to contexts within schools. Put simply, the *flipped classroom* learning model reverses the teaching in the classroom with homework that is done outside the classroom (Bergmann & Sams, 2012; Hamdan, McKnight, McKnight & Srfstrom, 2013). The teacher creates videos of him/herself teaching or narrates and records screencasts of work such as explaining and showing derivations of formula in mathematics or illustrations in science and geography on the screen. Alternatively, the teacher may make use of videos that are already freely available on the Internet, for example from YouTube, the Khan Academy or MIT websites. These instructional videos produced by the teacher, referred to as *vodcasts* for the remaining of this article, are uploaded onto a platform such as YouTube or the institute's learning management system (e.g. Blackboard, Moodle, Edmodo) for students to access in their own space and time. This access would be enhanced if students could make use of the mobile devices that they own to retrieve the vodcasts and other resources. The idea is for students to view and listen to the teaching in informal learning settings that is outside the classroom in preparation for the activities that are planned for them in the formal learning setting of the classroom in the next session of the course or subject. The argument for flipping the classroom in this way is to enable the more passive aspect of learning, that is, the absorbing of information conveyed by the teacher to be carried out at home, so that classroom time is reserved for more interactive activities where the teacher could help individual students with their issues and where peers could collaborate on tasks that build on the learning conducted at home.

The concept of inverting, flipping or reversing the classroom is not new. Practitioners on blog sites and discussion forums comment that they have practiced it as a repertoire of their teaching strategies for as long as they have been teachers. This has taken the form of getting students to read sections from their textbooks, try problems or research materials at home in preparation for the next lesson. With the advent of technology and learning management systems (LMS), higher education teachers often release readings and/or Powerpoints on LMS for students to view prior to lectures. With more schools now taking on board learning management systems, similar practices will become more prevalent. As technology evolves to be more user-friendly, teachers are able to video record, audio record and screencast record their teaching and upload them for student access via the institution's learning management system or YouTube prior to class sessions. With the ownerships of smartphones and tablets on the rise (BBC, 2008; Cerwall, 2012; Griffith, 2013; Sherman, 2013; Whitney, 2009) and with BBC online (2008) reporting that mobile net users are getting younger, access to these pre-recorded teaching in students' own space and time are becoming easier and could enhance flipped classroom learning. The one-to-one computing (Chan et al,, 2006) phenomenon where students have access to individual mobile devices (in particular laptops) is already happening in many secondary and tertiary educational institutions. Hence it is appropriate for researchers and teachers to conceptualise flipped classroom instructional and learning practices in light of mobility and ownership of mobile devices and how best to capitalise on them.

The paper will review the literature on flipped or inverted classroom in relation to existing conceptual frameworks and educational impact, discuss mobile – supported flipped classroom teaching and learning, present an example of a mobile-supported flipped classroom pedagogy and conclude by identifying benefits, issues and implications for flipped classroom practices.

2. Reviewing the literature

2.1 Theoretical underpinnings for flipped teaching and learning

Empirical-based evidence of the practice and impact of flipping the classroom in journal- and book-based literature is currently rather limited. However, the discussions of the topic in blog and other online sites (see footnote [1] for some examples of sites) is increasing in frequency. The general theoretical underpinnings for flipped classroom in the literature (e.g. Berrett, 2012; Flumerfelt & Green, 2013; Frydenberg, 2013; Marcey & Brint 2012; Talbert, 2011) and online discussions[1] is the use of videos to shift students' direct and passive learning in lectures in large groups in the classroom to individual learning spaces outside the classroom. In the classroom space, students would focus on and engage in activities that foster deeper understanding and higher order thinking through discussion, practical work and problem-solving tasks that they do individually or collaboratively in small groups. In order to solve problems, the students need to have a mastery of the concepts involved and would draw on the knowledge gained through viewing the videos at home. Individual students have the opportunity to clarify concepts taught in the videos that they are unsure of with the teacher in the classroom. Hence, the teacher takes on the role of a facilitator or mentor, moving around the classroom providing explanations, additional information and help to the students on a needs basis. By being able to pay attention to individual students, the teacher is also able to assess and gauge where each of them is at in the understanding of the content taught. This type of student-centred learning enabled by flipping the classroom is supported by practitioners who reported on student gains (Hamdan et al., 2013).

The flipped learning framework is supported by existing theories of learning - Bruner's (1966) cognitive constructivist learning theory and Vygotsky's (1962) social-constructivist theory. Constructivist theory posits that real learning can only take place when the learner is actively interacting with the learning materials and engaged in the learning process such as viewing and making sense of video content at home and discussing and collaborating with peers in the classroom in the flipped learning context. A difference between cognitive and social constructivism is that in the former, the teacher plays a limited role whereas in the latter, the role of the teacher is active and involved in helping students to grasp concepts by guiding and encouraging engagement in activities such as group work. Also central to Vygotsky's theory is the role of others (for example peers and parents) in mediating the learner's access to new experiences and knowledge. The student-centred feature of flipped learning means that students are actively engaging in their learning, taking responsibility for and having ownership of the learning. This active, personalised approach to learning using technology increases students' engagement and promote better learning outcomes (Michael, 2006; Ng, 2008).

The key features for effective flipped classroom practice have been identified by Pearson & The Flipped Learning Network (2013). These features were described as the four pillars of FLIP: (i) **F**lexible environment: the informal flipped learning allows for flexible individual learning in one's own space and time. Flipped classrooms allow for a variety of learning modes and may involve group work, independent study, research, performance, and evaluation. In-class time may be somewhat chaotic and noisy compared with the quiet, passive behaviour during a traditional lecture. In addition, flipped

[1] http://www.thedailyriff.com/articles/the-flipped-class-conversation-689.php
http://flippedlearning.org/FLN
http://blendedclassroom.blogspot.com.au/
http://www.knewton.com/flipped-classroom/

instructions also mean flexibility in pace of learning and assessment, designing appropriate assessments systems that objectively measure understanding in a way that is meaningful for students and the teacher. (ii) **L**earning culture - flipped learning requires a shift in learning culture, from teacher-centred to student-centred approaches of instruction where "students move from being the product of teaching to the center of learning, where they are actively involved in knowledge formation through opportunities to participate in and evaluate their learning in a manner that is personally meaningful" (Hamdan et al., 2013, p.5). (iii) **I**ntentional content - teachers need to evaluate the content they require their students to explore first in their own time outside the classroom, and the activities to adopt for active learning in the classroom such as peer instruction, peer-review, problem-based learning or individual research and (iv) **P**rofessional educator - flipped learning requires professional educators. Flipped professional educators are more important and more demanding than traditional educators. They are required to decide on when and how to shift group-based direct instruction to the individual learning space as well as how to maximize the face-to-face interactions between teacher and students. They are required to continually observe their students and assess their work in class, providing them with relevant feedback where appropriate. They take on a less visible role in the flipped classroom, are tolerant of classroom noise and disorder and are reflective practitioners.

2.2 Impact of flipped classroom on learning

As noted in the abstract for this paper, empirical evidence based on rigorous methodology investigating the impact of flipping the classroom is still scarce. There are several studies that show positive impact of the flipped classroom pedagogy on students' learning. In higher education, Marcey and Brint (2012) investigated the flipped classroom concept with a group of undergraduate biology students through cinematic lectures and inverted class pedagogy. Their results showed that in comparison with a 'control' group of traditionally taught students, there were statistically significant differences in learning outcomes with the flipped class students performing better on all the tests and quizzes. Frydenberg (2013) reported on the implementation of the flipped classroom pedagogy in a first year introductory Information Technology course, focusing on how the flipped strategies facilitated students' experiences learning about Excel concepts. The students' responses indicated that the flipped instructional methods captured their interests, challenged their thinking and contributed to their learning. In another study, Papadopoulos, Santiago-Román and Portela (2010) developed, implemented and assessed an inverted classroom model for an Engineering Statistic course. Their model consisted of a set of per-lecture modules and exercises online, a lecture that responded to the students' experiences in the pre-lecture activities and a problem-solving session after each lecture. The survey results showed that there was general endorsement of the inverted class model with 81% of the student group preferring the inverted format over the traditional method of teaching. Test scores revealed that the inverted group performed significantly higher than the control group.

At the school level, case studies reported by Hamdan et al. (2013) showed that in one school, the mathematics teachers found an increase in student engagement that exceeded expectations after flipping their mathematics classroom and that nearly three-quarters (73.8%) of students passed the state mathematics test, which is more than double the performance from just three years earlier. Another case study indicated that failure rates dropped by as much as 33% (Green, 2012) as a result of flipping the classroom. In another study, Flumerfelt and Green (2013) worked with a group of 23 at risk students using the flipped classroom approach and found that the students increased their online engagement and homework rates from 75% to 100%. Students' successes also increased by 11% in the flipped class compared with the control class.

It is evident from recent publications that interest in the flipped classroom concept is increasing. However, until more research is conducted, in particular on the attitudes, pedagogy and workload of teachers engaging with flipped classroom practices, the impact and uptake of flipping the classroom remains to be seen.

3. Mobile-supported flipped classrooms

Adwell et. al.(2007) noted the two winds of change that will impact on technology and education of the future as (i) the rapid advancement of technologies themselves and (ii) the changing of physical classrooms to 'learning spaces' where learning spaces could be physical, virtual or a blend of both. The integrated nature of these types of changes support the flipped classroom practice to enable learning that is independent, continuous and seamless . The transformation of 'classrooms' that are flipped into 'learning spaces' that are blended combines the physical space (classrooms, laboratories, home) and virtual space (supported by mobile technologies, learning management systems, Web 2.0 technologies etc) making these learning spaces more flexible and more multidimensional. Formally scheduled learning takes place in physical or virtual learning spaces and less formal learning in social learning spaces where interactions with peers could also be both physical and virtual. A study by Matthews, Andrews & Adams (2011) has shown that students who used social learning spaces demonstrated enhanced engagement with the learning than non-users. These spaces fostered active learning through social interactions, creating a better sense of belonging amongst the students. Mobile devices and apps are enablers of social learning where contact with peers or other experts online to obtain just-in-time assistance, through texting, messenger, email and blog/forum discussion could occur easily. Mobile device features and apps are also enablers of multimodal presentations of content that assist students to learn from a variety of format e.g. podcasts and vodcasts/simulations that are multimedia and visual. In today's society where technology penetrates almost all sectors of life, meaning making is increasingly more multimodal where the written-linguistic modes are integral of visual, audio, gestural and spatial patterns of meaning (New London Group, 1996). An implication of engaging with multimodality is that teachers and students have multiliteracies skills and knowledge, that is, the ability to construct meanings as well as decoding meanings, that is, drawing out meanings and interpreting information from *text* (written descriptions and explanations), *visuals* (images – photos, pictures, drawings, illustrations, graphs), *sound bytes* (e.g. podcasts, narratives, music), *videos* (multimedia: visual, sound etc), *maps* (static e.g. GoogleMap or dynamic e.g. Google Earth) and *conceptual models* (e.g. 3-D models such as DNA or 2-D models in the form of concept maps, diagrams). Multimodal means of representations in flipped learning cater to a wider range of students' ability and interest (New London Group, 1006; Ng, 2012), hence assisting with better learning that students do on their own at home.

3.1 Learning with mobile technology in flipped classroom

An example of how mobile technology could be used in a flipped classroom teaching the interdisciplinary topic of nanotechnology, suitable for years 9 and 10 students, is shown in the Appendix of this paper. The strategies used capture the social and multimodal learning advantages offered by mobile technology discussed above. The activities and content suggested are supportable by mobile devices although there will be more challenges if students are using smartphones of different mobile platforms. A more manageable strategy is the integration of a standard type of tablet (e.g. iPad or Samsung Galaxy Tab) for all students. Like any other teaching, flipped teaching that is supported by mobile technology requires that the teacher has good pedagogical skills. This includes having an understanding of how their students learn and what motivates them, their prior knowledge, the difficulties that they are likely to encounter, the abstractness of the concepts to be delivered and how best to vary teaching methods and activities to cater for the variety of interests and abilities in the class. In this respect, the nanotechnology example is not a rigid lesson guide and requires the teachers' discretion to extend an activity or task over two class periods rather than one, or alleviate the need to delegate homework if it is not necessary to do so.

Besides the social and multimodal affordances offered by mobile devices in supporting flipped learning, the mobile device also enables students to watch their teachers' vodcasts on the go e.g. on the bus or train, provided that the vodcasts have been downloaded to the students' smartphone or tablet via the institution's wireless facilities prior to leaving school. With the vodcasts ready for viewing in the students' mobile device, the probability of them viewing the vodcasts while waiting or travelling is higher. As bring-your-own-devices (BYOD) pedagogy is still in the very early stages of policy support and classroom implementation, a mobile supported flipped classroom would be better implemented in tablets-based schools. Designing mobile-supported flipped learning needs to consider:

- the sentiments of the students and ownership of the types of mobile devices (if it is BYOD); negotiate a plan of action with students in terms of taking responsibility for downloading and viewing the vodcasts in preparation for the next lesson.

- be clear with the students in terms of what the learning outcomes are and those that are achievable with mobile technology. It may be necessary to be flexible in terms of interacting with other tools as well.
- the need to release learning materials in small chunks, hence vodcasts created by teachers should be no longer than 15 minutes where explanations are to the point and in layman language, using examples that draws in experiences and events that students are able to relate to. The recorded teaching should be interesting, supported by images that enhance concept development and possible inclusion of other audio or short (1-2 mins) videos e.g. from YouTube or of other people speaking. Video recording the teacher speaking for 15 minutes in a lecture style is a poor form of flipping the classroom.
- ensure that the vodcasts' file sizes and types are manageable by different mobile platforms. Technical frustration is one way of demolishing motivation to learn. Hence allowing class time to trial out similar resources or apps that students need to use in the topic would be a useful way of preparing students for learning with mobile devices.
- ensure that that tasks that students have to undertake are pragmatic e.g. limiting writing on small devices and encourage the use of more visuals
- ensure that teachers and students have the necessary mobile literacy to carry out the activities for the topic and
- understand that flipped learning is already being practiced by teachers to varying degree and that a rigid flipped classroom style of instruction has its constraints and may not be suitable for all topics or disciplines.

4. Conclusion

Even though teachers have been flipping instructions for decades (but without the label), a contributing factor to the increase in current interest in the flipped learning concept is the evolution of technology and the one-to-one affordability of mobile technology. The flipped way of learning is essentially blended learning that is enhanced by mobile technology and which provides continuity between formal-informal learning in a seamless manner (Wong & Looi, 2012). The advantages that flipped learning offer include (i) enabling students to learn independently and at his/her own pace, rewinding instructional videos as often as (s)he desires in order to learn the material (ii) students who have been absent are able to catch up with the online materials prepared and uploaded by their teacher on learning management systems (iii) for the teacher, by spending more individual time with students in the classroom answering questions and providing frequent feedback to the students, the teacher develop both better relationship with the students and better understanding of their difficulties (iv) students are able to maximize class time for individual learning with the teacher and develop better peer relationship through teamwork and problem solving tasks and (v) for school children, parents are able to better understand what their children are learning through the vodcasts and be involved.

On the negative side (i) not all students do their homework which will pose more challenges for the teacher. Neither do all adults or parents support more homework for their children (ii) more technology-based homework means more screen time for the students which could impact on health (iii) the preparation of vodcasts could be time consuming and requires the teacher to have a good understanding of the video recording or screencast software, its editing features and how best to integrate the content into producing the vodcasts and (iv) where not all students have access to technology, teachers will need to ensure that they can access one e.g. a loan to them from the institution's repository of mobile devices.

As policy makers and schools are increasingly focusing on one-to-one access to (mobile) technology, its use to support flipped learning is ideal. However flipped instructions are not for all teachers or for all curriculum topics. There need to be careful planning and flexibility in adopting this strategy of learning in the classroom.

References

Adwell, J., Copeland, N., Forber-Pratt, A.. Gitonga, K., Kleber, K., Koplinski, C., Lawhead, M.J., Martin, R., Mattison, R. & Wilken, K. (2007). *Multiliteracies and education*. Retrieved May 23, 2011 from http://wik.ed.uiuc.edu/index.php/Multiliteracies_and_Education.

BBC (2008). Mobile internet usage on the rise. Retrieved March 8, 2011 from http://news.bbc.co.uk/2/hi/technology/7748372.stm

Bell, B. S. & Kozlowski, S. W. J. (2009). Toward a theory of learner-centered training design: An integrative framework of active learning [Electronic version]. In S. W. J. Kozlowski & E. Salas (Eds.), *Learning, training, and development in organizations* (pp. 263-300). New York: Routledge.

Bergmann, J., & Sams, A. (2008). Remixing chemistry class. *Learning and Leading with Technology*, *1*, 22-27.

Bergmann, J., & Sams, A. (2012). Flip your classroom: Reach every student in every class every day**.** Alexandria, VA:ISTE.

Berrett, D. (2012). How 'flipping' the classroom can improve the traditional lecture. *The Chronicle of Higher Education, 12.* Retrieved July 23, 2013 from http://moodle.technion.ac.il/file.php/1298/Announce/How_Flipping_the_Classroom_Can_Improve_the_Traditional_Lecture.pdf

Bruner, J. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press

Cerwall, P. (2012). Ericsson mobility report. Retrieved 5 June, 2013 from http://www.ericsson.com/res/investors/docs/2012/ericsson-mobility-report-analyst-brief-nov2012b-a4.pdf

Chan, T.W., Roschelle, J., Hsi, S., Kinshuk, Sharples, M., Brown, T., Patton, C., Cherniavsky, J., Pea, R., Norris, C., Soloway, E., Balacheff, N., Scardamalia, M., Dillenbourg, P., Looi, C.K., Milrad, M. & Hoope, U. (2006) One-to-one technology-enhanced learning: an opportunity for global research collaboration. *Research and Practice in Technology Enhanced Learning, 1*(1), 3–29.

Green, G. (2012). *The Flipped Classroom and School Approach: Clintondale High School.* Presentation at the annual Building Learning Communities Education Conference, Boston, MA. Retrieved August 5, 2013 from http://2012.blcconference.com/documents/flipped-classroom-school-approach.pdf

Griffith, C. (2013). Desktop sales nosediving as tablets take off: Gartner. *The Australian* newspaper. Retrieved May 14, 2013 from http://www.theaustralian.com.au/australian-it/it-business/desktop-sales-nosediving-as-tablets-take-off-gartner/story-e6frganx-1226641477479

Hamdan, N., McKnight, P., McKnight, K. & Srfstrom, K. M. (2013). A review of flipped learning. Retrieved July 23, 2013 from http://www.flippedlearning.org/cms/lib07/VA01923112/Centricity/Domain/41/LitReview_FlippedLearning.pdf

Frydenberg, M. (2013). Flipping Excel. *Information Systems Education Journal*, *11*(1), 63-73.

Flumerfelt, S., & Green, G. (2013). Using Lean in the Flipped Classroom for At Risk Students. *Educational Technology & Society*, *16* (1), 356–366.

Lage, M. J., Platt, G. J., & Treglia, M. (2000). Inverting the classroom: A gateway to creating an inclusive learning environment. *The Journal of Economic Education*, *31*(1), 30-43.

Marcey, D. J., & Brint, M. E. (2012). Transforming an undergraduate introductory biology course through cinematic lectures and inverted classes: A preliminary assessment of the clic model of the flipped classroom. In *Biology Education Research Symposium at the meeting of the National Association of Biology Teachers.* Retrieved July 28, 2013 from https://www.nabt.org/websites/institution/File/docs/Four%20Year%20Section/2012%20Proceedings/Marcey%20&%20Brint.pdf

Matthews, K. E., Andrews, V. & Adams, P. (2011). Social learning spaces and student engagement. *Higher Education Research and Development*, *30*(2), 105-120

Michael, J. (2006). Where's the evidence that active learning works? *Advances Physiology Education*, *30*, 159–167.

New London Group. (1996). A pedagogy of multiliteracies: Designing social futures. *Harvard Educational Review*, *66*(1), 60-92.

Ng, W, 2008, 'Self-directed learning with web-based sites: how well do students' perceptions and thinking match with their teachers?', *Teaching Science*, vol. 54, no. 2, pp. 26 – 30.

Ng, W, 2012, *Empowering scientific literacy through digital literacy and multiliteracies.* New York: Nova Science Publishers.

Papadopoulos, C., Santiago-Román, A., & Portela, G. (2010). Work in progress—Developing and implementing

an Inverted Classroom for Engineering Statics. In *Frontiers in Education Conference (FIE), 2010 IEEE* (pp. F3F-1). IEEE.
Pearson & The Flipped Learning Network (2013). *Flipped Learning Professional Development*. Retrieved August 5, 2013 from http://www.pearsonschool.com/index.cfm?locator=PS2aNj
Sherman, J. (2013). Tablet sales on the rise, to surpass PCs by the end of year. Digital Trends. Retrieve May 9, 2013 from http://www.digitaltrends.com/mobile/tablet-sales-on-the-rise-to-surpass-pcs-by-end-of-year/
Strayer, J. F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research*, *15*(2), 171-193.
Talbert, R. (2012). Inverted classroom. *Colleagues, 9*(1), article 7.
Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
Whitney, L. (2009). AdMob: iPhones, Android phones on the rise. Retrieved December 7, 2011 from http://news.cnet.com/8301-1035_3-10366193-94.htm
Wong, L. H., & Looi, C. K. (2011). What seams do we remove in mobile-assisted seamless learning? A critical review of the literature. *Computers & Education*, *57*(4), 2364-2381.
.

Appendix

An example of mobile-technology supported flipped instruction and learning

Objectives 1: Probe for prior knowledge and **2**: Introduce nanotechnology with an aim to motivate and interest

In class:

Probe:(i) what students know: open class discussions about the meaning of nanotechnology (ii) small group discussions of stimulus statements e.g. from Jones, Falvo, Taylor & Broadwell (2007). Examples include:

- there are currently biological nanomachines that naturally exist in your body
- NASA plans to build a space elevator that would use carbon nanotubes to move materials from Earth to outer space
- self-cleaning toilets are now available, these toilets are made with nanotechnology that keeps the porcelain clean
- through nanotechnology, steaks can be made atom-by-atom such that cows are no longer needed to produce the meat.

Pre-test on 'Size matters' on SurveyMonkey, students access and complete on mobile device.

1.How big is a nanometer compared to a meter? List one object that is nanosized, one that is smaller, and one that is larger but still not visible to the naked eye.
2.Name two properties that can differ for nanosized objects and much larger objects of the same substance. For each property, give a specific example.
3.Describe two reasons why properties of nanosized objects are sometimes different than those of the same substance at the bulk scale.
4. What do we mean when we talk about "seeing" at the nanoscale?
5. Choose one technology for seeing at the nanoscale and briefly explain how it works.
6. Describe one application (or potential application) of nanoscience and its possible effects on society.
(source for questions: http://www.ck12.org/book/NanoSense-Student-Materials/r1/section/1.1/)

Objective 3: Students to have a sense of the smallness of 'nano'

Outside class:

Read and conceptualise nanotechnology and its scale at the nanometer level at http://www.ck12.org/book/NanoSense-Student-Materials/r1/section/1.1/ and/or watch YouTube at https://www.youtube.com/watch?v=TuljCWV6gLU or at https://www.youtube.com/watch?v=xlYIex2TF5g&list=TLiIHfHdEFEqQ

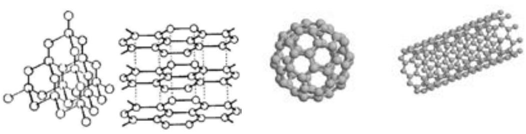
In class:

Students undertake a short online quiz to assess what they have understood about nanotehcnology.
Define nanotechnology with class.
Students start keeping a glossary of terms encountered in the topic in a note-taking app e.g. *EverNote* for smartphone and for tablet (*Pages* for Apple devices, or *Kingsoft Office* for Android devices)
Conduct a practical activity that sorts a wide variety of materials into km, m, cm, mm and nm groups to get a sense of dimensions. Students work in small groups to come up with 8 -10 images for each scale and present to class for verification.

Objective 4: Students to understand property changes with size and structure

Outside class:

Revise atoms and molecules: teacher create vodcast for students to view at home.
Install *Jmol Molecular Visualization* app for Android devices or *Ball & Stick* app for Apple devices. Explore different structures e.g. water, ethanol, glucose etc
Properties change with structure: Find images for the structures of diamond, graphite, bucky ball and nanotube (see below) - these are all made of carbon atoms but are arranged differently and demonstrating different properties, hence different uses.
Create a folder for nanotechnology in *Dropbox* and save images.



In class:

Discuss the materials and research on the Web (i) their uses and (ii) how the shape and arrangement of atoms fit the

use.
Construct a table in a word processor - insert images and describe structure and uses
Construct (phyiscally) a paper bucky ball with template at http://invention.smithsonian.org/centerpieces/ilives/kroto/buckyball.pdf

Outside class:
Read about nano particles and sunscreen at http://www.cancer.org.au/preventing-cancer/sun-protection/nanoparticles-and-sunscreen.html

In class:
Properties change with size of materials: Use sunscreen as example. View titanium oxide and zinc oxide on the molecular visualisation apps
Nano-sunscreen experiment: In grops of 2, investigate and compare the differences between zinc cream that stays white when applied with nano-sunscreen which is transparent when applied. Use UV sensitive beads to investigate which materials, e.g. paper, cloth, aluminium foil, students' sunglasses, plastic, cellophane, face foundation etc. will block out UV rays better. Include testing different brands of sunscreen. Video record or take photos of experimental results to be included into report. Write report of the investigation in the mobile devices using a word template that the teacher has created.

Outside class:
View teacher's vodcast on the electromagnetic spectrum
Create a Nanotechnology ePortfolio webpage e.g. on *Wordpress* where students can showcase their work as their learning progresses. Write an Introductory paragraph about nanotechnology; place table and report constructed above on webpage.

In class:
Relate the electromagnetic spectrum and how colours are seen to the nano sunscreen experiment. Learn about UVA, UVB and UVC and why they are harmful.
Students undertake set problems relating to electromagnetic spectrum and undertake an online quiz to reflect on understanding at the end of the period

---

Objective 5: Students to know about the development of instrumentations (microscopy) in advancing nanotechnology research

Outside class:
View teacher's vodcast on an overview of the evolution of microscopy from magnifying glass to the light microscopy (compound microscope) to the electron microscopy (scanning tunnelling microscope) to the atomic force microscope. The latter 2 enables nanoscale imaging.

In class:
Research further and create a PowerPoint (using *Keynote* for Apple devices or *SoftMaker Presentations Mobile* for Android devices) or Prezi presentation on either the electron or atomic force microscope and its uses.
(Note: Android devices do not support Prezi so students will need to create a PowerPoint or use laptop/desktop to create the Prezi)
Students complete presentation (at home if necessary) and upload his/her presentation to his/her ePortfolio site and sms, email or use messenger (e.g. *WhatsApp*) to send link to two peers for review.

Outside class:
Peers review the presentations on mobile devices and email, sms or send via messenger their comments to the student who created the presentation.

Objective 7: Students to understand about the applications of nanotechnology in their everyday lives

In class and outside class:
Students learn about the applications of nanotechnology by researching artificially synthesised miniature 'things' that could work inside cells e.g. nanobots and useful things outside the body for our day-to-day living e.g. self-cleaning glass; anti-bacterial bench top or food containers; anti-odour and stain resistant clothings, cleaner water, band-aid delivering drugs (hence no injections) and nanodiamonds (4 nm).
Students work in groups of 2 for this task and collaboratively create a glog, video or PowerPoint presentation that will be presented to the class.