10 Active learning strategy

ACTIVE LEARNING STRAGEGY 10

Dynamic Problem Based Learning (dPBL)

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THE STRATEGY:

DYNAMIC PROBLEM BASED LEARNING

Problem Based Learning (PBL) is based on real-life, authentic and complex problems to which there is rarely a singular 'correct' solution. This can challenge students as the majority of their learning may have previously been focused on terminal exams and getting the correct answer onto the exam paper. Another issue is the use of group work which can present challenges to students, particularly those who prefer to work alone and wish to maintain control on individual grades. For the academic, these additional challenges add further complexity to the assessment of PBL-based modules...so why bother?

Quite simply, both staff and students benefit immensely from a (dynamic) problem-based learning environment (dPBL). Presenting a relevant problem in a contextualised scene, combined with a careful adjustment of the lecturer's role, enhances the learning experiences of all students, while simultaneously offering a stimulating teaching environment for the academic. Adopting a (d)PBL approach allows the students to see both the macro and micro interconnections during the problem-solving process and how the problem could be directly related to their everyday experiences. Inclusion of dynamic changes (e.g. through dPBL) to the scenario during the problem-solving process mimics the fluxing real world environment and can result in enhanced engagement, deeper learning and a more meaningful experience.

The three pillars of (d)PBL are absolute requirements in adopting this teaching and learning approach: the problem, the tutor and the assessment (Strobel & van Barneveld, 2009). Each of these need to be carefully considered and can be adopted to align with the length of time allocated to the activity and the level of assessment.

RESOURCES

(d)PBL is best carried out in a non-tiered classroom setting while flexible furniture configurations allow participants to move freely and engage with each other more effectively. The scenarios and problems that will drive student learning should be provided in written format to each group. Students could be encouraged to use their own Internet-enabled devices (e.g. phones, tablets, laptops) and connect to the local WiFi during the (d)PBL session. If a 'Bring Your Own Device' (BYOD) approach is not suitable, access to breakout Internet-connected computer rooms should be made available. Beyond this, very few other resources are needed to run a (d)PBL session.

WHAT YOU CAN DO TOMORROW

Develop a small scenario-based problem, which will stretch students a little beyond their current understanding. The problem should be a real-life problem, or life-like at least, in order to capture the student's interest. Initially provide students with an opportunity to work individually and to develop their own solution to the problem. Following this, allow students to form into groups of their own choosing (pairs, threes, fours and some larger groups should naturally form) and give time for each student to pitch individual solutions for the problem to their new group.

Once the pitching process is completed, ask each group to design a group solution to the problem adopting elements from the individually pitched ideas. Groups are then required to present the group solution to the rest of the class. Seek feedback (perhaps using the Two Stars and a Wish approach: two positive comments and one suggestion for improvement) from the class on each group's solution. If time allows, the facilitator could 'talk aloud' their approach to solving the problem so as to offer insight into an experienced problem-solver's mind.

Image 1: Working in pairs.

STEPS FOR IMPLEMENTATION

A (d)PBL approach can be adopted into any classroom, for any discipline, and can be executed by following these steps:

STEP 01

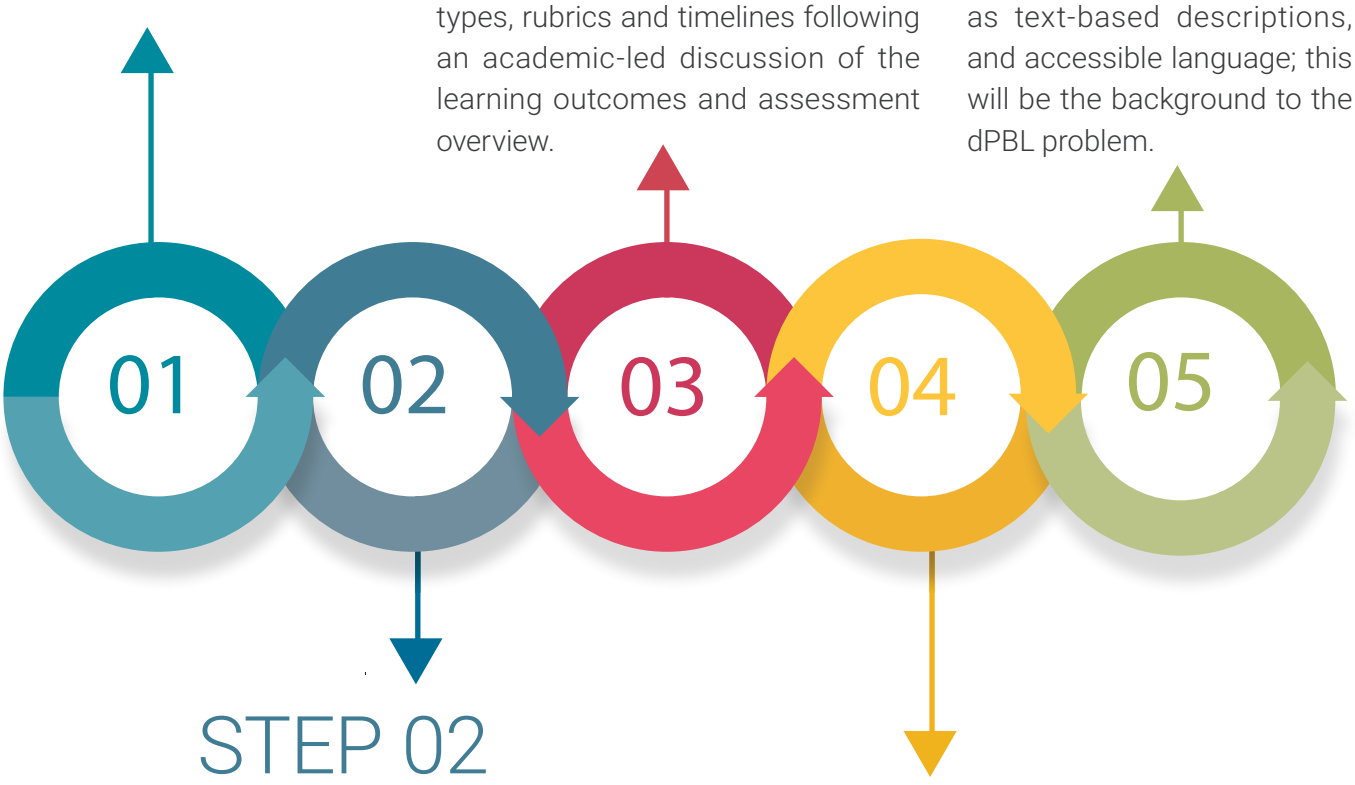
Introduce the concept of (d) PBL to the cohort and allocate time to discuss the approach including barriers, pros and cons.

STEP 03

Centralise the students in all decision-making processes once the groups are formed. This can include, where possible, the co-design of the assessment strategy, whereby the academic and the student groups negotiate appropriate assessment types, rubrics and timelines following an academic-led discussion of the learning outcomes and assessment overview.

STEP 05

Present a relevant real-life (or life-like) scenario in the context of your module using judicious presentation, including multimedia as well as text-based descriptions, and accessible language; this will be the background to the dPBL problem.



STEP 02

Form student groups that will work together to solve the (d)PBL problem. Groups can be pre-selected by the academic in a targeted (e.g. based on student position in the class) or random (e.g. based on a lottery) fashion. Alternatively, a student-centred approach to group selection can be used whereby the students self-select/create groups (Tuckman and Jensen, 1977).

STEP 04

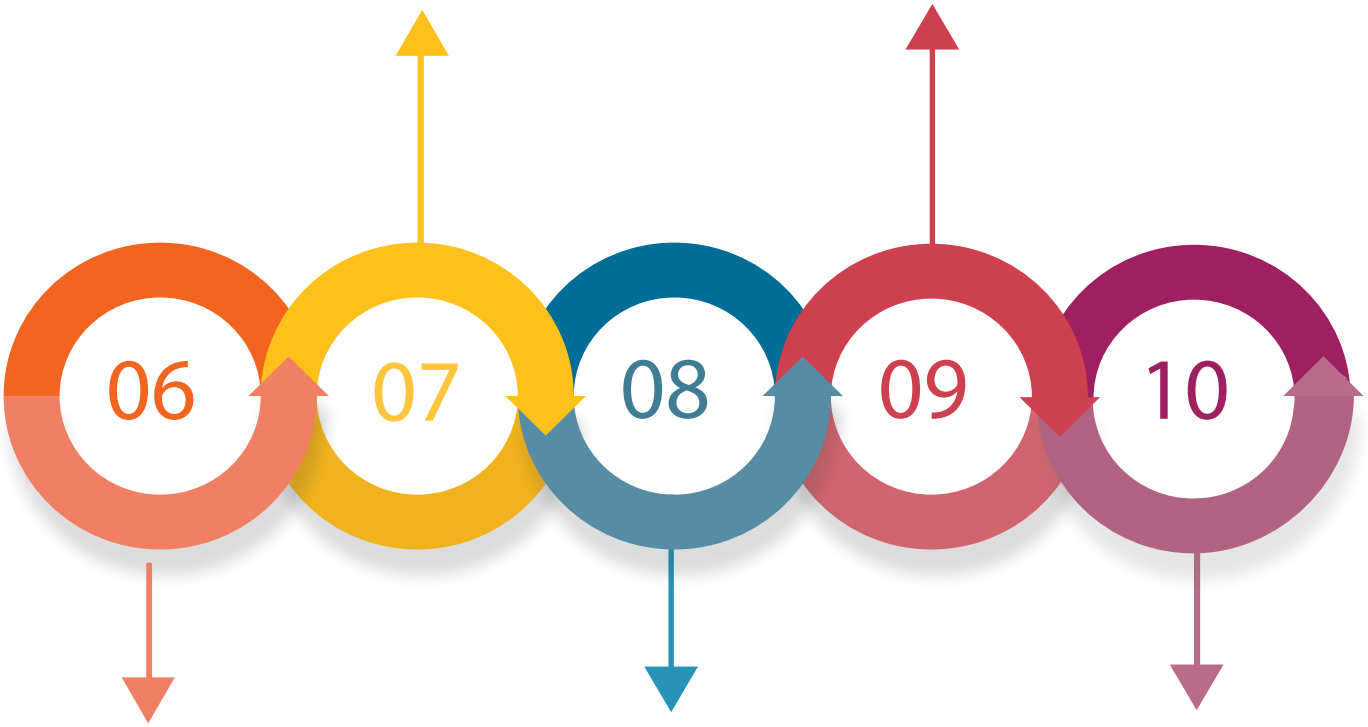
Ensure the problem-solving process, as well as the 'solution', is clearly valued in the agreed assessment strategy and grading rubric (Glasgow, 1996, as cited in Tai & Yuen, 2007).

STEP 07

Pose directional questions to guide students beyond their knowledge gaps towards a deeper understanding of the problem and potential solutions. An example of this would be to ask student groups 'why' to push students beyond their existing knowledge (White, 2006; Azer 2005). Allow students to make mistakes, to fail and to struggle.

STEP 09

Introduce an additional challenge to the original problem to maintain the momentum and energy of (d) PBL over time. This will force the students to reflect on their decision pathway to the point of change.



STEP 06

Ask the students to use their prior knowledge to identify the current limitations of their knowledge and how to go about filling in these gaps in order to address the dPBL problem.

STEP 08

Give students appropriate time to think, reflect and discuss with their peers to help students to overcome particular areas of confusion; however, set a limit on this 'thinking time' so the students can work towards an actionable end-point (Croom & Stair, 2005).

STEP 10

Celebrate student achievement, through group presentations or ePortfolios for example, highlighting the learning gains achieved by the students and their proposed solutions to the problems.

OVERCOMING PUSHBACKS

STUDENTS DO NOT ENGAGE WITH THE PROBLEM

Students can struggle with the open-endedness of the problem. The introduction of a dynamic change can further challenge students and may lead to further alienation and disengagement from the problem. One approach to overcome this apathy is to ensure a tangible output is the focus of each scaffolded activity. Each activity brings the student groups closer to their solution to the problem and the output will only come to fruition if the group works together. There may be gaps in both the individual student's and group's knowledge, and although the initial sense of hopelessness will be evident, guided scaffolding of student discussion can help ensure that the outcome represents the best combined efforts of the group (Hakkarainen, 2011).

STAFF BELIEF THAT STUDENTS CAN'T SOLVE COMPLEX PROBLEMS

Following on from the student fear of open-ended problems, with no 'correct' answer, teaching staff may also struggle with how to facilitate a class that is based on (d)PBL. Attempting pseudo-PBL by designing a problem that would eventually converge on the same 'correct' answer may be an attempt to design a standardised learning event and protect participants from the complexity of real-life problems. Forcing each student to think, imagine, conceptualise and theorise in the same way is not possible, and does not develop critical and independent learners. The diversity within student groups should be embraced, along with celebrating each student's own personal (and group) abilities to solve complex problems.

STUDENTS DO NOT ENGAGE WITH GROUP WORK

Central to successful (d)PBL is the integration of group work as core to the problem-solving process and subsequent individual learning and personal development (Savery & Duffy, 1995) while the two most important aspects of (d)PBL are the group process and self-knowledge (Fenwick, 2002). During (d)PBL the development of self-knowledge is seen to mirror group work with key elements including learning to understand different perspectives within the group, to cooperate, to lead small groups and to manage conflict within groups. At an undergraduate level the development of these soft skills is an absolute requirement, and oftentimes lecturers can struggle to find suitable ways to teach and assess these soft skills (Kumar & Hsiao, 2007). Compounding this is the general aversion to group work by undergraduate students.

In order for a (d)PBL approach to be most effective, each group must be capable of juggling multiple projects, thinking critically, writing academically and working as a coherent group. These are skills that staff can struggle to 'teach' and students equally can struggle to 'learn' but they are the skill set that employers require in graduates. This tangible link to employment may be used as a lever to encourage student engagement with their groups. Additionally, modern modes of communication and technology, e.g. group wikis and cloud-based presentation tools, can be used by students and staff to maintain communication outside formal face-to-face events, further enhancing the student skill set.

STUDENTS QUESTION THE ASSESSMENT APPROACH

In (d)PBL, the process involved in attempting to solve the problem is as important as the outcome or final solution. As such, it is important to monitor and assess both aspects of the activity. Additionally, group work is pivotal to the success of (d)PBL. However, this can cause tension during assessment and grade allocation. Clarity and fairness are required to engage students in the assessment strategy and aspects of the process/product and group/individual need to be equally valued. For example, the individual learning journey can be documented and examined through the use of (e)Portfolios (e.g. Liu et al., 2009), while reflection is best reviewed through personal and critical reflective writing (e.g. Brears et al., 2011). The group learning journey can be detailed in a wiki (e.g. Xie & Kim, 2012) and the group collaboration vetted by a suitable peer assessment (e.g. Papinczak et al., 2007). Several other alternative product and process assessment methodologies are discussed by MacDonald (2005) through a comprehensive description of various case studies.

CASE STUDY

OVERVIEW

In a final year Advanced Bioprocessing module (5ECTS), students were taught through an immersive, scenario-driven dynamic problem-based learning approach. In this approach students were emailed weekly memos from a fictitious biopharmaceutical CEO that challenged them to design the company's new blockbuster drug. Along with developing a novel stream for the company, the students were asked to create their bioprocess (including industry standard piping and instructional diagrams), establish standard operating procedures to support the company's manufacturing operations, and complete their due diligence in terms of patent licence and market opportunity. Each week the memo guided the students towards a set of goals that, cumulatively, brought the students from the initial extremely open-ended question through a set of smaller problems. As the initial problem was so open, the final product of the dPBL approach is different for each student cohort and therefore the groups learn from each other throughout the module.

The class was delivered as a back-to-back two-hour double session in a traditional tiered lecture theatre to a mixed class of approximately 35 students. The students were a mixture of food and pharmaceutical disciplines. The students' first problem was to form cohesive working groups around common areas of interest (i.e. independent of discipline background). This allowed students who would not normally work together to form new groups around a common goal. This generates strong buy-in from the student cohort; the groups are self-selected around a topic they want to explore. They determine what they want to learn and how they want to learn it through the scaffolding of the weekly memos (see Table One).

Table One: An overview of the weekly memos and the tasks/problems each memo asked the student group to address.

Memo No.	Topic of Memo
One	Form group + review current research areas (peer reviewed literature)
Two	Prepare presentation on new target product
Three	Develop digital portfolio to document development
Four	Prototype logistics for small scale production
Five	Annotated Review of a process related publication and SOP creation
Six	Market comparison and patent database review
Seven	Science communication for product marketing

A typical learning week soon took on a common trend for each of the groups as they tackled each memo (see Figure One). The weekly problems were too big for anyone member of the group to complete alone; therefore, the students had to work together. As a group they determined how best each group member could contribute to their group's advancement of the weekly problem, and therefore the larger, overarching problem. This allowed the weekly face-to-face classes to mimic a collection of 'working group' meetings common in the industry and were chaired and coordinated by the students.

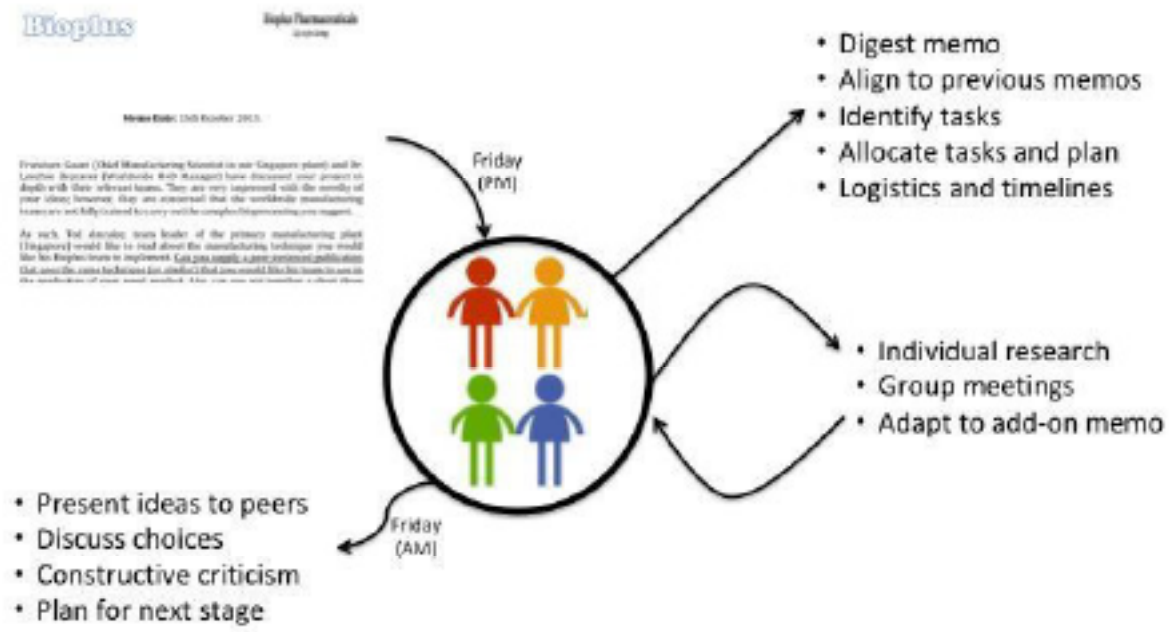


Figure 1: The typical weekly cycle for the dynamic Problem Based Learning Approach.

Figure 1: The typical weekly cycle for the dynamic Problem Based Learning approach to teaching Advanced Bioprocessing. The cycle is initiated by the release of the memo to the group (noted as occurring on Friday evening). The group then rotates through the various learning activities comprising both individual and group activities. The cycle concludes at the next class (denoted as Friday morning in this case) where the student groups present their process progress, discuss and provide peer feedforward for future development.

Once the students were familiar with the arrangement of the student-centred learning, and all groups had actively taken responsibility for their learning, dynamism was introduced to reflect real-life challenges faced in the biopharmaceutical manufacturing industry. These dynamic challenges were often released between classes and the student cohort was expected to have prepared a response for the next face-to-face class. These challenges reflected topical issues pertinent at the time to add to the realness of the scenario; for example, pirate attacks on cargo shipping around the east coast of Africa was particularly problematic during one iteration of this module and this was included as a challenge (i.e. the ship containing a key raw material for each student bioprocess had been hijacked so the students needed to consider an alternative manufacturing strategy). All problems were themselves scaffolded by the 3C3R approach and this allowed for a transparent and fair assessment to be developed and executed. The 3C3R model consists of two classes of components: core components and processing components. Core components include content, context, and connection, and are used to support content/concept learning; processing components, composed of researching, reasoning, and reflecting, concern the learners' cognitive processes of learning and problem-solving skills (Hung, 2009).

The assessment strategy examined both the process (blogs, reflective essay) and the product (ePortfolio, annotated review, teaching class, infographic) as part of a 100% continual assessment (CA) approach. The assessment approach, which was as both individual and group based, was designed by the student cohort and facilitated by the academic (see Table Two).

Component	Weighting (%)
Blogs (do 10, top three graded)	15%
Reflective Essay	15%
Annotated Review	10%
ePortfolio	35%
Teaching Class	15%
Infographic	10%

Table Two: Agreed assessment approach table

Table One: Student-designed CA approach. Items noted in bold were group-based CA (typically groups of three) and those in regular font were individually completed CA.

The module was evaluated by the student cohort and the key emergent themes of student responsibility, group-based learning, industrially relevant learning, personal development and reflection emerged. The students took ownership of their groups project; however, they were willing to support their peers in a constructive learning environment. Through ongoing and committed reflection, each student identified their strengths (and weaknesses) and integrated their skills into their groups weekly workflow in order to maximise the productivity of their group. In doing so, the members of each group assisted each other as part of a dynamic, functional group that mimicked a real industrial setting in the safe environment of the classroom. Student groups were free to make mistakes, learn from them and to build their solution to the open-ended problem.

SUMMARY

This chapter outlines an incremental approach to traditional problem-based learning where the initial problem is structured into sequential and logical sub-problems that can be perturbed by the inclusion of unforeseen change. This dynamic element allows further contextualisation to be brought to the problem-solving journey, while simultaneously mimicking real-life settings that the student will likely encounter once they graduate. Exposing the student to these situations in a safe environment allows the student to develop confidence in their problem-solving abilities, learn from their mistakes, and also enhance their soft skills through continuous critical reflection, group work and peer dialogue.

There are barriers to the adoption and integration of (d)PBL and these tend to focus on assessment and group work. To addresses these issues, clear and fair assessments (and guidelines) must be utilised, perhaps with the inclusion of the student voice during the design, focusing on

the individual and group contribution to both the problem-solving process as well as the final 'answer' (i.e. the product). The design of a good problem for (d)PBL oftentimes results in a problem that has no correct answer. As such the journey can be enlightening and rewarding for the students and staff as they explore together the possible 'correct' avenues, and, through self-directed learning, academic facilitation and peer dialogue, deep learning can be achieved.

FUTHER READING

General reading on PBL with multidisciplinary exemplars of best practice
Barrett, T. & Cashman, D. (2010). A Practitioners' Guide to Enquiry and Problem-based Learning. Dublin: UCD Teaching and Learning. Freely available from https://www.ucd.ie/t4cms/UCDTLI0041.pdf

Magennis S. & Maguire, M. (2015). An Introduction to Enquiry/Problem based Learning. Freely available from http://eprints.maynoothuniversity.ie/6824/1/NUI_Aishe_Booklet_PBL.pdf

Dynamic Problem Based learning example (Chemistry specific).
Overton, T. L., & Randles, C. A. (2015). Beyond problem-based learning: using dynamic PBL in chemistry. Chemistry Education Research and Practice, 16, 251-259

TEMPLATE

Template One: (d)PBL design

Hung (2009) describes a nine-step approach to problem design based on the 3C3R concept (3Cs = content, context, connection and 3Rs = research, reason, reflection). Incorporating this model into your problem design will ensure that your problems are designed to challenge, motivate and encourage students to learn through tutor-guided questioning and self-directed research and reflection. Use the template below to structure your (d)PBL design.

The 3Cs: these are the concepts and content that the problem will focus on.	
Component	**Relate this component to your (d)PBL problem**
Content	
Context	
Connection	
The 3Rs: these are the cognitive processes of problem solving	
Component	**Relate this component to your (d)PBL problem**
Research	
Reason	
Reflection	

TEMPLATE

Template Two: Process Assessment Guide

Assessing the Process component of (d)PBL can be one of the more challenging aspects for staff and worrisome for students. This component needs to be fairly and authentically assessed. One simple but effective method is that of Tai & Yuen's (2007) which is based on a three-pronged assessment approach. Tai & Yuen (2007) describe the use of a multiple mixed assessment methodology to assess the students' ability to apply acquired knowledge and skills in a variety of authentic contexts and work collaboratively to solve complex problems (termed Performance Assessment), to examine the students' ability to document their learning journey (termed Portfolio Assessment) and evaluate the students' autonomous learning through critical self-reflection (termed Reflection and Self-Assessment).

Component	Where in your process assessment design is this component noted?	Is it authentic and why?	How will it allow students to display their achievement of the learning outcomes fairly?	What type of assessment will this be (e.g. written, oral etc.)?
Self-Reflection				
Peer's Reflection				
Task Completion Reports				