ONLINE COURSE DESIGN IN HIGHER EDUCATION: CASE STUDY: SUSTAINABLE POLYESTER PRODUCTION

Lappeenranta–Lahti University of Technology LUT

Master’s Programme in Energy Technology, Master's thesis

2025

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ABSTRACT

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Online course design in higher education: case study: sustainable polyester production

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The purpose of this thesis is to design and publish an online course focusing on Polyester production and the transition from fossil fuels to sustainable alternatives on the LUT MOOC Platform. The course content is based on a previous research conducted by Vilho Pakkanen in connection with the Threading-CO_2 project which focuses on the production of polyester from CO_2 that has been harnessed from waste streams such as the industrial sector.

The design of online courses like traditional classroom courses revolves around the presentation of information and then the assessment of the students' knowledge of the topic. In this ever-changing world, the need for improved online learning is continually increasing especially since the Covid-19 pandemic when online learning platforms saw an explosion of growth. Various pedagogical techniques are need in order to ensure the course's content is relevant and engaging enough to retain the learner's attention, particularly when looking at the high levels of online course dropouts. While also aiming to stimulate the learner in a meaningful way during assessments and online activities.

The integrity of which has been called into question during the advent of AI. A vast array of AI resources and tools have become available to both the learner and teacher over recent years both improving and hindering learning. Different AI services are reviewed and compared.

Overall, the success of an online course is determined by a wide range of variables but must ensure that the required information is being conveyed to the learner and that they are absorbing it in a worthwhile manner.

ABBREVIATIONS

AI	Artificial Intelligence
LMS	Learning Management Systems
ILO	Intended Learning Outcome
GHG	Green House Gas
EG	Ethylene Glycol
TPA	Terephthalic Acid
BHET	Bis(2-hydroxyethyl) Terephthalate
PET	Polyethylene Terephthalate
rPET	Recycled polyethylene Terephthalate
bio-PET	Bio-Polyethylene Terephthalate
PLA	Polylactic Acid
PHA	Polyhydroxyalkanoate
bio-PTT	Bio- polytrimethylene terephthalate
CCUS	Carbon Capture, Usage and Storage
DAC	Direct Air Capture
FAQ	Frequently Asked Questions
LCA	Life Cycle Assessment
SPOC	Small Private Online Courses
API	Application Programming Interface
LLM	Large Language Models

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DECLARATIONS

Turnitin

The originality of this thesis has been reviewed with the Turnitin similarity checking service.

AI usage

The author of the thesis, Alexander Bennett-Tighe, used the following AI-tools during the preparation of the thesis:

1) Scopus AI
   a) Purpose of use: Identification of relevant academic papers
   b) Explanation of the use of the tool: The AI provided suggestions which were then used after being reviewed for relevance to the topic and validity.
2) Google AI overview
   a) Purpose of use: Provides links to useful sites based on google searches
   b) Explanation of the use of the tool: The AI provided a brief summary in relation to google searches along with the corresponding links which were checked if reliable and useful for the study before being used.

Responsibility

The author, Alexander Bennett-Tighe, takes full responsibility for the content of this thesis and has reviewed and edited the content generated by the possible use of AI tools.

1 Introduction

Following the global pandemic in 2020 and subsequent lockdowns along with other social distancing polices, the vast majority of educational institutions from primary and secondary schools to universities were forced to adopt an online approach to teaching similar to what is seen in Open Universities (Dindar et al, 2021). Whether that was with the use of applications such as zoom or Microsoft teams to conduct classes in a more traditional way with the teacher lecturing to the class or, with the use of online platforms such as MOOC and Moodle where teachers can upload material for the students to learn from and return assignments to (Pertiwi et al, 2021). Even though the world has returned to normality it terms of the lifting of lockdowns and educational institutions reopening doors for in person classes, universities still rely on these online platforms as a means to upload lecture materials and for students to return assignments, especially with the sizes of classes and, when the assignments require a specific program to run for example in the technical fields. It is therefore important to continue to develop and revise online courses to enhance the learning experience for the students and to ensure that they are able to receive the same quality of education as before the migration to electronic learning, particularly in an age where Artificial Intelligence (AI) has become so readily available.

For the purpose of this thesis, the focus will be on Massive Open Online Course (MOOC), a type of digital learning modality. MOOCs aim at providing courses to anyone, anywhere in the world, free of charge while also having no limit on the amounts of participants or deadlines in general, allowing the learners to study at their own pace. The platform on which the courses are published varies depending on country and can further stem into various different sites such as in the US the main MOOC platforms are Coursera, edX and Udacity among others which all provide a wide range of courses. Whereas in Finland, the MOOCs are published on to university specific variations of MOOC.fi (Pickard, L. et al, 2025). Development of the courses have seen remarkable growth since their inception in 2011 as seen in Figure 1, with 2021 alone producing some 3100 courses (Shah, D. 2021). Participation has also seen enormous growth with one such course offered by Yale university at the start of the pandemic alone receiving 1.5 million participants within the space of a single month (Papadakis, S. 2023). As of 2021, MOOCs had 220 million combined registered users, with the largest uptick in users found at the start of the pandemic with 60 million new registrations in 2020 alone (Shah, D. 2021).

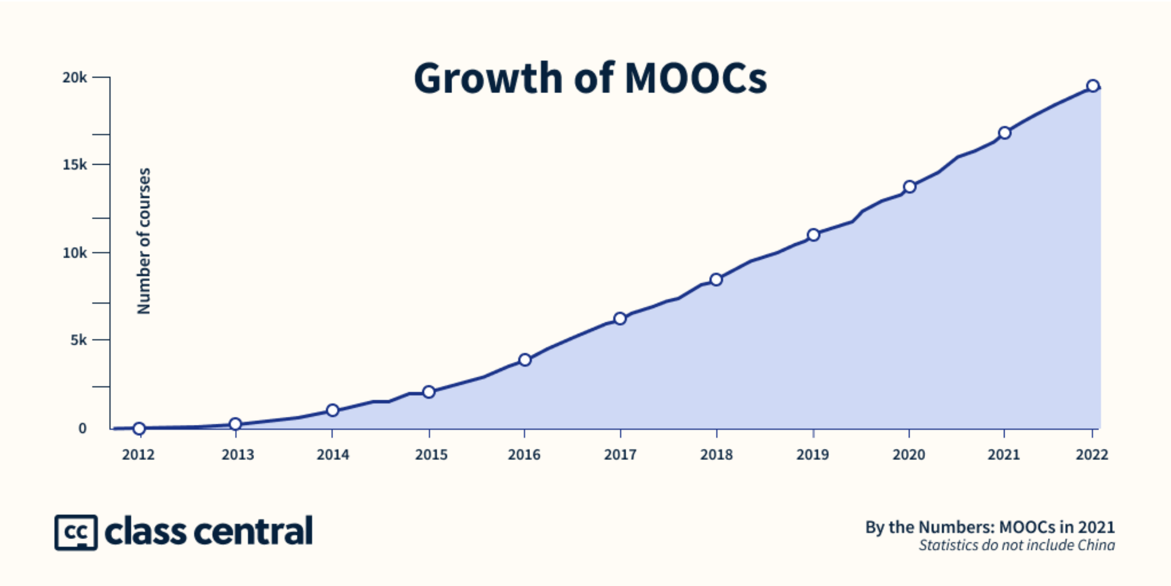

Figure 1: Growth of MOOC courses form 2012- 2021 (D. Shah, 2021)

The objective of the thesis is to design a MOOC titled “Polyester production: Transitioning from fossil fuels to sustainable alternatives”.

The aforementioned MOOC course will revolve around the Threading-CO_2 project which aims at the production of renewable polyester from waste CO_2, removing the need for fossil fuel-based feed stock that is used in the more traditional production of polyester. The project consists of thirteen members, one of which is LUT university, with the aim of join research and development to enable scalability of the technology and decreasing the environmental impact of the products production without hindering the quality and properties of the polyester (Aspire2050, 2022). A pervious thesis was conducted on the topic of “Polyester production: transitioning from fossil fuels to sustainable alternatives” by Vilho Pakkanen for the purpose of turning it into a MOOC course and on which this MOOC will be based on (Pakkanen, 2024).

The implementation will follow on from a previous MOOC course published by LUT University, “Climate Action: The Role of Digital Transformation in the Process Industry”, available at https://mooc.lut.fi/, also within the scope of the Threading-CO_2 project at the start of 2025 (Aspire2050, 2022).

The typical layout of a MOOC revolves around the interactive course mindset where the participants have various tasks to complete throughout the course which allows them to consolidate the information that they have learnt and check that they have understood it. The style of the platform also means that there is no need for further input from the course provider once they have released the course which, in turn also allows for instant feedback for the learners. This however can lead to some rather binary tasks for the learner, with regards to tasks revolving around true of false questions and multiple choices. In addition to content preparation, a key focus of this study will be how to navigate and improve the tasks for the participants in a way that ensures the information has been absorbed. Available AI resources in Learning Management Systems (LMS) for both teachers and learners will also be covered.

2 Massive Open Online Course (MOOC) design

Content alone is often insufficient to ensure that participants of the courses will absorb fully the material, characterised by the large numbers of dropouts or incomplete courses (Wang, et al. 2021). Content and assignment preparation go hand in hand, with the content enabling the learner to partake in the assignment, and the assignment re-affirming the knowledge learned from the course. Course participants level of satisfaction, according to a study carried out by Li, found that a variety of predictors indicated a higher chance of satisfaction including but not limited to; amount of previous online courses, goal setting and highest level of education (Li 2019).

A study carried out in 2020 found that improved design quality of the MOOC course correlated to an improved participation rate and increased satisfaction (Al-Adwan, 2020). It is therefore imperative that both content and the design of the course are focused on, during the development of any new course as concluded by Alario-Hoyos, with the suggestion that there needs to be a plethora of assignments throughout the course to ensure understanding and to retain the learner's attention (Alario-Hoyos, et al, 2014). Throughout this section, the overall course structure will be analysed with both the design and the contents of courses being studied.

Although the focus will be on the MOOC format of online courses, it is just one of many variations commonly known as Learning Management System (LMS). LMS provides the framework to host courses, track learning and enrolments. These features are particularly beneficial for the large volumes of users and the variety of media used within the course itself (Lonn, S. 2009). Knowledge of the chosen LMS not only improves the rate at which an educator can produce such a course but also aids in the pedagogical and learning goals. Incorporating LMS features such as discussion forums, automated grading, embedded multimedia and modular content further aids in these goals. Examples of other LMSs include Google Classroom (Google, 2025), SAP Litmos (Litmos, 2025) and Totara Learn (Totara Learn, 2025).

In the design of Massive Open Online Courses (MOOCs), the establishment of clear guidelines and Intended Learning Outcomes (ILOs) are essential for fostering effective and scalable learning for participants. Clear guidelines mainly refer to the specific instructions and expectations provided to learners regarding the course structure, how to participate, assessment along with possible deadlines, and communication. With clear guidelines having been linked to improved users' satisfaction and increased completion rates (Alraimi, et al., 2015). ILOs is define as what learners are expected to know, understand, or be able to do after completing a course instead of what is to be taught (McGuinness, 2011). They work by clearly stating what the desired outcome is without having to complete the course first, help focus the content of the course and assignments towards an end goal while also aiding the learner to confirm that they have met the success criteria (Rune Hjelsvold, 2020).

2.1 Content preparation

Content preparation: Focusing on content preparation is crucial in the case of online courses but in particular, MOOC course creation because MOOCs operate at large class sizes, are often self-paced course, and instructor-less environments. Given the often-large numbers of participants on such courses, it leads to the obvious realisation that the audience will be heterogeneous and come from a range of backgrounds. Content that is prepared to a high standard ensures that it is accessible, inclusive, and pedagogically effective for this broad of an audience (Laurillard, 2012).

Self-paced learning: Self-paced learning is partly to do with the learner's wiliness to learn but also relies on the content being interesting, which leans again towards the retention of the learners and completion rates (Al-Adwan, 2020). Without the presents of a teacher figure during the course, all explanations, instructions, and learning materials must be self-contained, clear, and comprehensive from the outset, linking back to ILOs to reduce the risk of misunderstanding which can also negatively impact retention rates (Hollands & Tirthali, 2014).

Learning and teaching methods: Another approach is both learning and teaching methods which combine both technologies and pedagogic techniques (Bartoletti, 2016). These can come in a range of forms from multiple modalities of content to connectivism and reflection. Multiple modalities or more commonly known as multimedia, refers to the use of combinations of media forms be it text, audio, pictures both static and moving or animations in the effort to stimulate various sensory organs with the aim of increasing the level of understanding and retention of new information (Guan, et al, 2018). Multimedia as described by Mayer is, however, only an aid in learning and does not provide learning in itself, rather it is transferred to the short-term memory, known as sensory memory from the sensory organs such as eyes after watching or reading information and ears after listening to information. This is then transferred to the working memory when the learner starts to think about what the information is actually stating and only with the combination of existing knowledge does beneficial learning take place as illustrated in Figure 2 (Mayer, 2024).

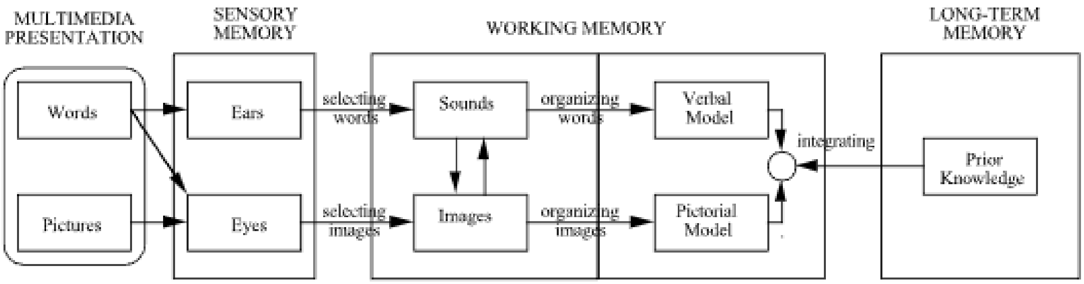

Figure 2: Cognitive theory of multimedia learning (Mayer, R. 2024)

Media usage: However, in a similar study conducted by Mayer in 2014, attention was drawn to the importance of relevant media being used. Three lessons were made, one with little to no extra media with the basic text, the second with visually appealing and motivational media but not necessarily relevant to the lesson and the third with relevant and motivational media. Concluding that purely visually stimulating media that is not relevant has a positive effect on attention but does not aid in retention of information whereas, the third option resulted in improved learning and reduced distraction compared to the other two options (Mayer, 2014). It is therefore important to be attentive to which media is included in the course to ensure it is relevant to the learning outcomes. Connectivism in this sense refers to focusing the learning on the learner while enabling them to generate links between their learning and the sources from which the information originates (Bartoletti, 2016). While reflection for both the student and the teacher involves both reviewing what has been learned but also being critical in challenging our understanding in relation to how we can implement this knowledge (Hickson, 2011).

Paragraphs: Following on from the visuals of image media, the visuals and layout of the text is also important in the course design. Shorter paragraphs allow for more bite sized information absorption which intern reduces the risk of cognitive overload which prevents the working memory from retaining and processing information (Sweller, 1988). These shorter paragraphs are also visually more appealing and less intimidating and offer a sense of progress when reading, particularly within the online setting where skimming text instead of reading the whole body of text has become normalised (Weinreich, et al, 2008; Liu, Z. 2005).

A more compartmentalised text allows the reader to pause, reflect, and mentally organise the segments that they have just read before moving on following Mayer's segmenting principle (Mayer, R. 2009). Short paragraphs make it easier to locate specific information via pattern recognition and repetition when reviewing or revising (Liu, 2005).

Microlearning: The style of short form content that goes hand in hand with short paragraphs can be referred to as microlearning. This is where compact sized information, whether that be short paragraphs, a quick video or other digital media, is used to provide concentrated learning in a quick and comprehensive manner (Linder, 2007). Microlearning can be split into two main categories, that of *microcontent* and *micro activities*, with the microcontent being the information provided to the learner and the micro activity being used as a way to quickly check the understanding of the information (Kamilali, et al, 2015). With the ever-growing popularity of mobile applications such as TikTok and Instagram where short form content has seen significant growth, it leads to the realisation of embracing the appeal for short form content for educational purposes (Vera, et al, 2024).

A study was conducted with a focus on the combination of MOOCs and micro learning, with various forms of microlearning being implemented resulting in positive feedback from both the experience and future potential of such design features (Bothe, et al, 2019). Another benefit of microlearning in a MOOC format is the ability to take it anywhere and learn on the go with mobile applications such as Coursera's mobile application. Given that phones are carried everywhere, there is nothing holding a learner back from the opportunity to learn new things (Kamilali, et al, 2015).

It has also been noted that the shorter content allows for clearer connections between what has been learned and its relevance, much like how the shorter paragraphs allow for time to quickly reflect in between each segment. However, further study still needs to be carried out on the learners intended learning outcomes (ILO) following microlearning and is therefore best used in combination with other teaching methods (Taylor, et al, 2022).

Sections: Following on from short form content is self-contained sections or compartmentalised sections. Similarly to how short form content works, the segmentation of sections within the MOOC provides benefits such as reducing the mental load while also improving information retention levels (Mayer, 2009). Self-contained sections are a core design principle in effective MOOC design. They allow for discrete units that can stand on their own without requiring extensive background from previous sections but add to the whole in a meaningful way. They further enable the learner to customise and tailor the learning experience to their needs by allowing them to choose their own path within the MOOC whether that is by skipping basic/prior knowledge sections or revisiting specific skills without the need to retake the whole course (Margaryan, et.al. 2015).

Non-conical navigation: Non-conical navigation of MOOCs is a growing trend among users (Kim, et al. 2014) and only stands to reason that embracing this ability to pick and mix the segments will only benefit the learner. A trial run of independent modules for medical students was carried out at Marshall University which furthered topics taught in lectures. The participants reported positively to the modules with students feeling that they had a higher level of understanding and also receiving on average higher grades than compared to before the trail (Serrat, et al, 2014). Although this was outside the context of MOOC, the notion that smaller modules that can be accessed in whatever order the learner decides, benefiting the learner can be applied in the MOOC setting but also highlights the benefit of combining MOOCs with more traditional methods of teaching.

Zhang has taken the idea of segmented content one step further with the idea of automatically partitioning videos into smaller clips that are then searchable by the learner for quicker and smoother navigation and revision within the MOOC (Zhang, et al. 2016). This could be particularly useful for courses that upload lecture videos as part of the course allowing students to be more time efficient in finding what they are needing quickly and thus improving the learning experience. Another helpful aspects of self-contained segments is the reusability of each segment in various other course, for example a climate change segment could be reused over several course where it is an underlying topic or relevant background information.

Story telling: A method that has been used to combat the low completion rates is story telling. This can cover a large variety of techniques such as fictional tales, characters or viewpoints. Examples of this was studied by Johnston, et.al. with a fictional murder mysteries on forensic courses that takes the learner step by step though a crime scene and explores examination techniques like fingerprint and DNA collection in individual modules to generate an overarching narrative, or a sensational news story within a journalism course with each section linking relevant skills to the story each week (Johnston, et al. 2016).

Characters: The use of a Characters or *caricatures* can also aid in tying a course together as found within the ‘Tomorrow’s Mobility’ MOOC, where a character was created to join the learner throughout the course, and by completing the assignment of each module of the course the learners could aid the character in his own challenge, resulting in a higher completion rate compared to other similar courses (Thirouard, et al, 2019). Johnston examines another course in which the choices of the participant have effects on a fictional character ‘Billy’ after learning about him throughout the course. This use of a character and situations based on real-life were found to have aided in understanding of topics and course enjoyment (Johnston, et al. 2016).

However, not everyone is convinced that story telling is a viable or effective tool within a MOOC structure, following a statistical analysis of a course Höfler, et.al. that concluded there was not any strong correlation relating to the implementation of storytelling and completion rates (Höfler, et al, 2017). They do go on to acknowledge short coming of the research by stating that each course can have wildly different values based on a variety of factors such as the topic and the time frame of the course and that further study is needed, particularly on courses with larger participation numbers (Höfler, et al, 2017).

Contextualization: A similar yet different technique to story telling is that of contextualization, which uses background information, connecting ideas and information or real-world examples to enhance the relevance, the learning outcomes and the retention of that information (Son, & Goldstone, 2008; Perin, 2011). A MOOC on climate policy could for example include localised data or regional case studies depending on the location of the learner. Son goes on to give an example of improved reading ability in children with the use of objects that relate to a provided text, signalling an improved level of learning with the use of this technique, however the use of physical objects is not possible or at least impractical when creating a fully online MOOC course. Research carried out by Perin, highlighted a low usage of contextualization in community college course in the USA, suggesting that educators may be unaware of its existence, the lack of effort to change existing course to a more contextualized model and lack of funds as possible reasons for this and will need to be tackled in order to improve the usage rates (Perin, 2011). MOOC courses can be contextualized linguistically and or culturally to improve accessibility and comprehension across a diverse audience, allowing more people to access education globally.

When a course is missing context for certain groups of people it can impede their ability to learn, this has led to the development of the "Frugal MOOC Model" (Mariam, & David, 2019). The concept of a frugal MOOC is a combination of four main aspects: local stake holders, customisation, the needs of learners and the technological infrastructure as seen in Figure 3 (Mariam, & David, 2019). Each of these is able to be changed to better suit the needs of the learners in a way that enhances their ability to learn no matter their situation.

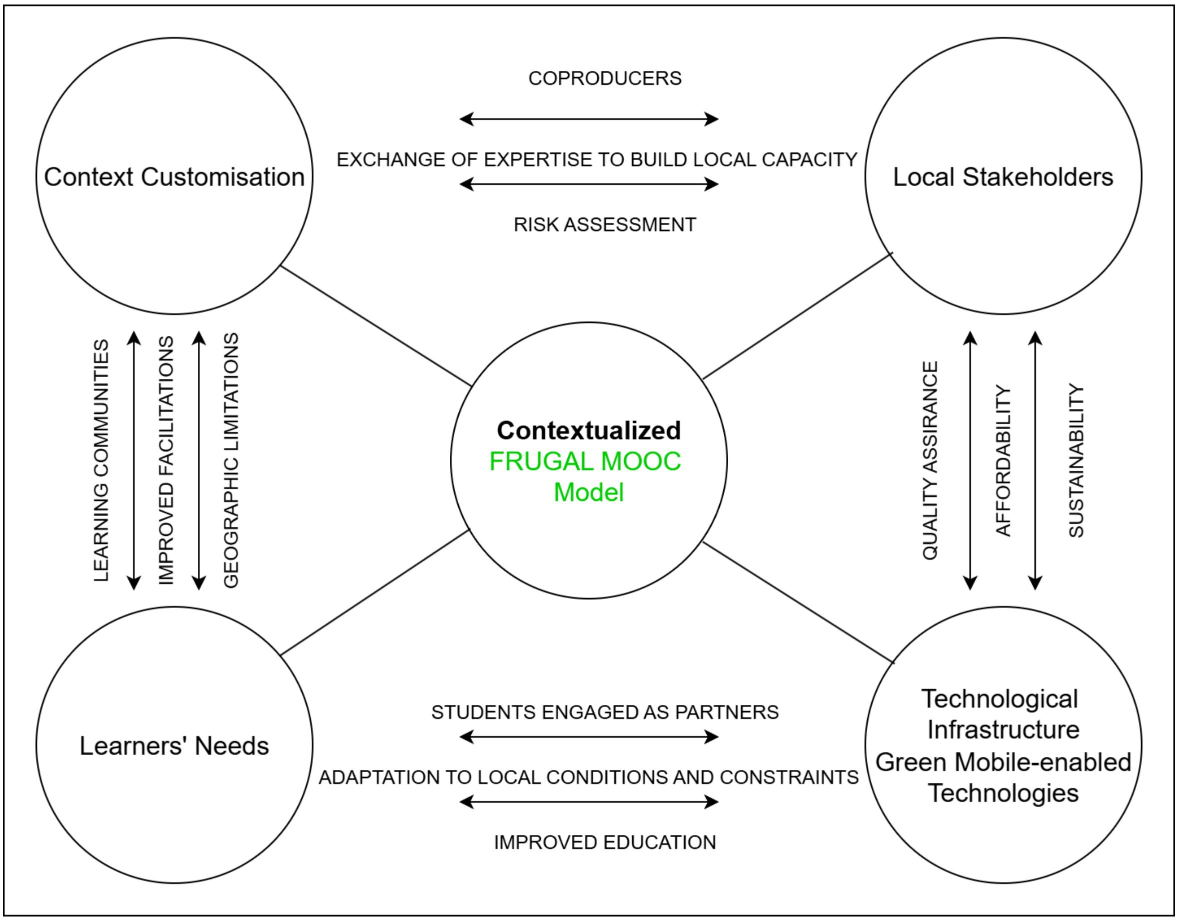

Figure 3. Visual of a Frugal MOOC (Mariam & David, 2019).

Contextualization is not only beneficial to the learner but also the teacher in providing an insights into their courses performance and the students interactions and results with the course by quantifying what is deemed acceptable quality and worth credit (Douglas, et al. 2019). An example of this provided by Topali follows that if an answer to a task is stated in a video and the student gets the question wrong, it could suggest that this student has not watched the video (Topali, et al, 2022). This knowledge could then be used to improve further iterations of the course or highlight students that may be underperforming for whatever reason.

Digital literacy: Digital literacy is another key aspect of course design that should be taken into consideration particularly for those students who may be new to learning online such as students from developing nations or older generations returning back to continue their education. This can result in hardships in accessing the content, managing studies and learning the information (Bradford et al, 2007).

AI: With the ever-growing presence of AI in people's daily lives through services such as route planners, chat bots, automatic vacuum cleaners and text correction, it makes sense that the education sector follows suit by incorporating the ever-evolving technology. Following the explosion of publicly available AI tools in recent years, many educators are exploring ways to leverage them for a wide range of purposes. These can enhance the accessibility of information inline to some of the devices already looked at such as increasing the available media types, provide personalised information, providing assistance and support to both the understanding of the courses content and also the learner's ability to effectively use the learning platform, or simply translating text to a specific language (U.S. Department of Education, 2023).

2.2 Preparation of assignments

When it comes to the assignment preparation, the main challenge is to test the learner without the use of simple recall and understanding questions that are so often used in MOOCs. With Bali, M. recognising that such forms of tasks do not provide any meaningful development within the context of an online course, given that the information can still be easily assessed even during the assignment (Bali, 2014). Achieving any level higher than understanding on the Bloom's Taxonomy scale as seen in Figure 4, is perhaps the main challenge in designing meaningful task (University of Florida, 2020).

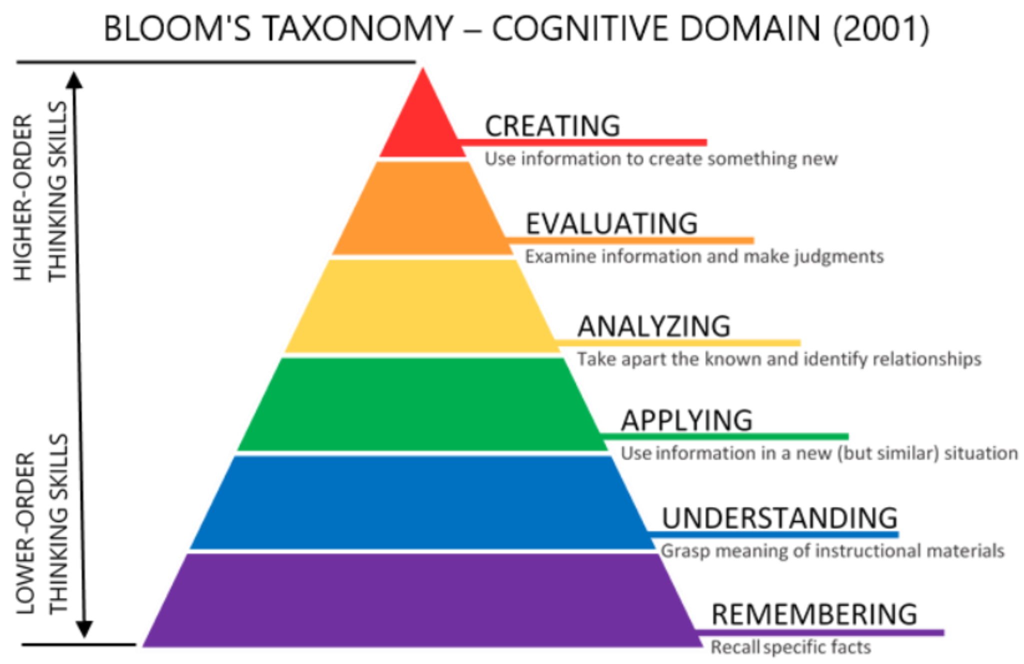

Figure 4: Bloom's Taxonomy for the cognitive domain (University of Florida, 2020)

In Bali's research, four courses were analysed, with 75% of them containing multiple choice questions which would only relate to the lower two levels of the Bloom's taxonomy scale: remembering and understanding (Bali, 2014). It is therefore imperative to focus not only on the content of the course but also the assignments use to check that the student has not only remembered and understood but can use that new knowledge to apply, analysis and evaluate in the confines of a MOOC.

Variety: A benefit of the MOOC platform is the flexibility and wide range of possibilities when it comes to the type of assignments that can be provided. These include but are not limited to multiple choice questions, essays, short written answers, timelines, drag and drop, peer assignments, personal reflection and media creation (University of Helsinki, 2024; Margaryan, A & et al. 2014; Admiraal, et al, 2015; MOOC LUT Platform, 2025).

It is then the challenge of the educator to develop these into a form that stimulates the higher orders of thinking skills. However, even after three years of notable success since there conception in 2011, a study conducted in 2014 found that the vast majority of courses it encountered still relied heavily on quiz type questions, whether they be a weekly test or the final exam. Peer graded assignments and discussion forums accounted for less than 20% of the studied courses as seen in Figure 5 (Watted, & Barak, 2014).

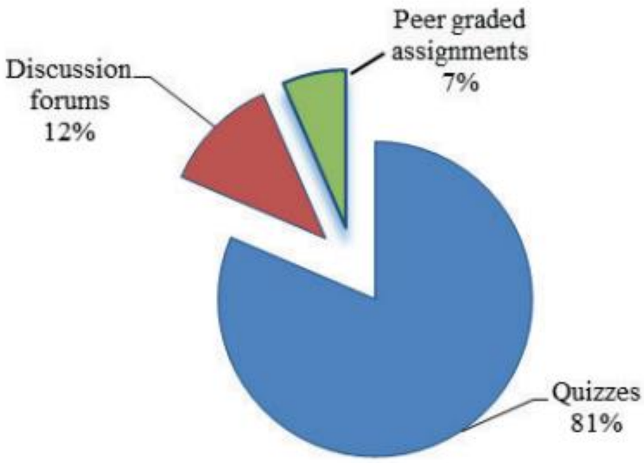

Fig. 1 Distribution of MOOC assignments.

Figure 5: Distribution of MOOC assignments (Watted, & Barak, 2014)

This reliance on low level cognitive tasks has led some to call into question the validity of accredited MOOCs especially when compared to the more traditional forms of higher education teaching, with its tried and tested methods (Admiraal, W. & et al, 2015).

Question Design: The assignment design revolves around either the inbuilt software on the MOOC platform or from H5P hub which enables the use of similar interactive content to that of the inbuilt system. H5P, is a embedded system that supports various HTML5 content, granting access to interactive tools (H5P, 2025). Figure 6 shows some of the possible options when it comes to generating assignments from the MOOC platform whereas Figure 7 shows those provided by the H5P software.

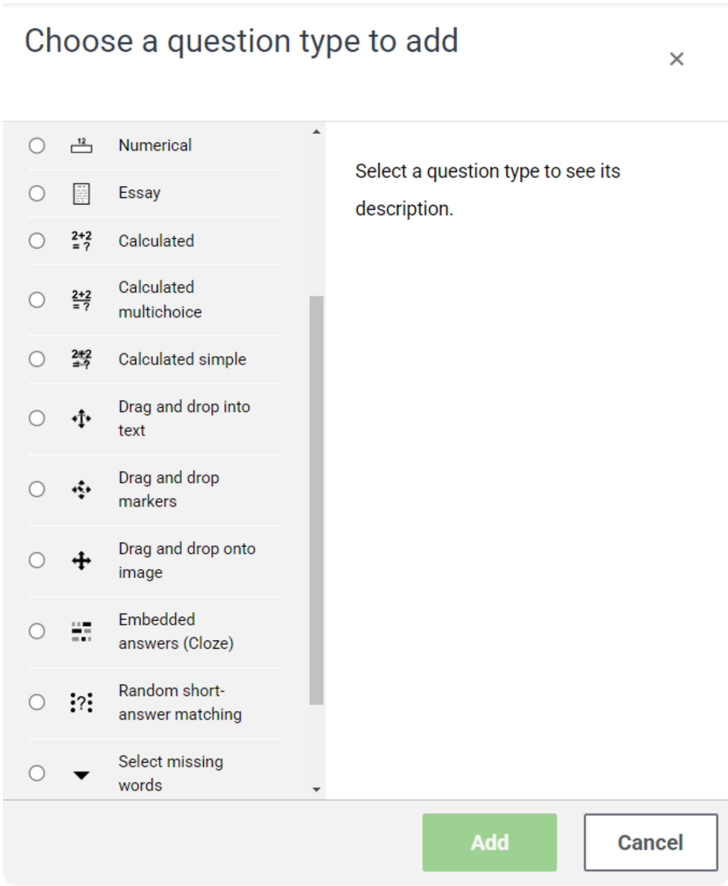

Figure 6, Screenshot of MOOC assignment creator (MOOC LUT Platform, 2025).

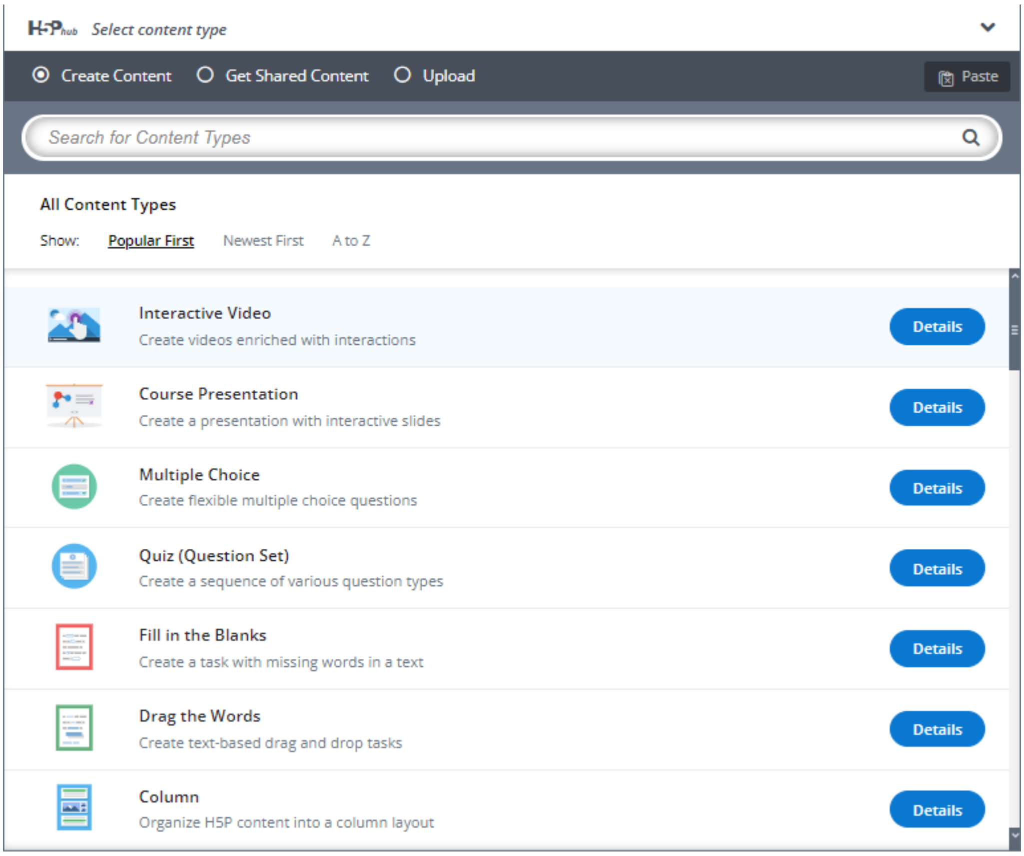

Figure 7, Screenshot of H5P assignment creator (MOOC LUT Platform, 2025).

As can be seen in both figures, they offer similar possibilities when designing questions, with basic models such as multiple choice and fill in blank questions available, however H5P has the opportunity for slightly more variation in questions compared to the inhouse model allowing for things such as interactive videos and audio recorder (MOOC LUT Platform, 2025). However, the design should incorporate similar aspects to that of the content preparation, with features such as aligning the assignments to the Intended Learning Outcomes (ILO) by having relevant and meaningful questions.

Accessibility: Linking back to a point made in the content preparation section (section 2.1), being able to access the content in multiple languages as well as having options such as text to speech enabled considering the wide variety of learners that participate in MOOC ensures that it is compliant with the W3C Web Content Accessibility Guidelines (W3C, 2024).

Combatting Cheating: It is also important that due to the MOOC, or any online course, providing academic accreditation, that the assignments are done in a way that uphold academic integrity and the validity of the accreditation (Currie, G. & et al, 2023). This is especially important in the age of Artificial intelligence (AI), where answers can be easily obtained with little to no effort using Large Language Models (LLMs) such as ChatGPT or Microsoft Copilot. Although there are beneficial ways to incorporate AI into and online learning environment which will be analysed in a later chapter (chapter 4) of this thesis, the drawbacks have to be taken into account. Currently there is no global census yet about how to combat these problems, individual institutions have, however begun to implement their own regulations in relation to online teaching. One example of this is from the University of Zagreb, Croatia, which provided instructions to its faculty (Bubaš, & Čižmešija, 2023). These included but not limited to, providing example exams in simulated circumstances so that the students would know how to take the real exam, negating possible technical problems later on, reduced the ability to revisit previously submitted answers and not providing the correct answers immediately after taking the test to aid in reducing the possibility of sharing answers, as well as less closed questions which allow for a range of possible answers.

Personalised learning: An aspect that is often overlooked is the human factor when it comes to education and the importance of human interaction within a learning setting, particularly when the lack of direct contact between students and teachers can hinder the detection of cheating or misconduct (Balalle, Pannilage, 2025). This is something that is only set to become more strained with the increase of AI and technology in an education setting (Al-Tkhayneh, et al, 2023). Moore noted that many students would prefer more personalised learning, something that can be somewhat achieved in a traditional classroom where the teacher can offer assistance to students struggling but which is not often the case with regards to an online environment (Moore, & Blackmon, 2022). In this respect, AI could also assist by making the learning more personalised for the student in a way that improves learning and engagement.

Peer Assessment: A perhaps more simple work around the lack of human interaction for online courses is peer to peer assessments. Peer to peer assessment is another way to develop learning by having students mark each other's work, giving them access to other perspectives and encouraging interactions between students. The use of grading rubrics or grading aids also can highlight to the participants what constitutes as valued answers and thus in turn assist in learning and critical thinking (Naudu, Sevnarayan, 2023; Ibarra-Sáiz, et al, 2020; Alcarria, et al, 2018). Figure 8 shows the steps and benefits to develop one's own learning experience within peer assessment (Ibarra-Sáiz et al, 2020). As shown, both the assessor and assessed benefit from this form of assessment, with feedback being provided along with new realisation in the form of self-regulation and development.

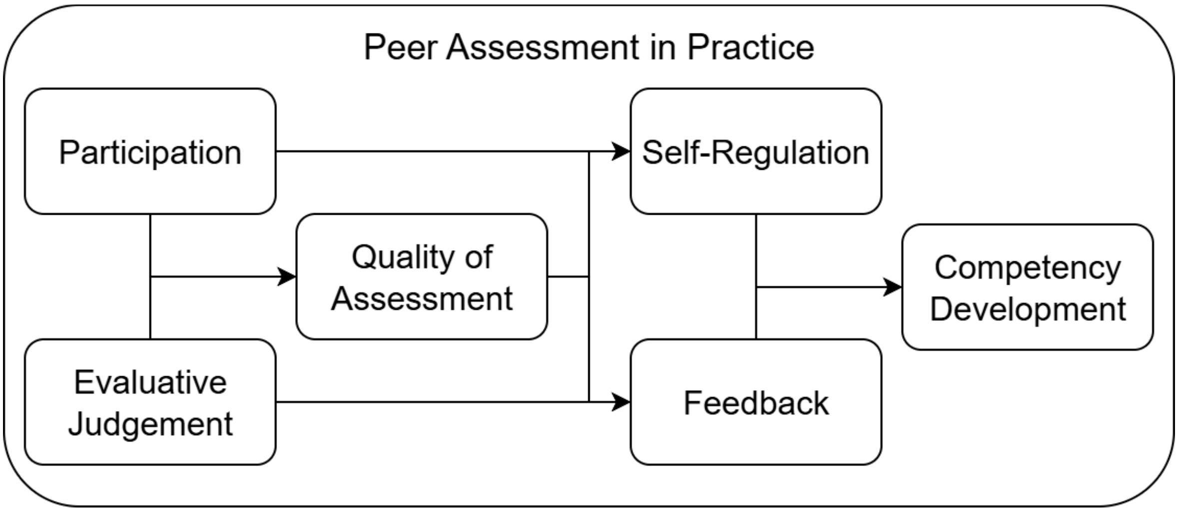

Figure 8, Flow diagram of Peer Assessment process (Ibarra-Sáiz, et al, 2020).

Feedback: The incorporation of end of module and end of course feedback submissions as a required assignment also promoted both reflection and aids in the reinforcement of newly acquired knowledge. The inclusions of 'the three questions', where am I going? how am I going? and where to next? as studied by Hattie not only aid in the student's ability to acknowledge that they have learnt something but also understand where there is room for development and further understanding (Hattie & Timperley, 2007).

Another perhaps understated challenge is that due to the large numbers of participants often associated with MOOC courses is how to provide feedback to the learner in a meaningful way that does not rely on mass automation or the use of other learners to peer grade each other's work (Daradoumis, et al. 2013).

3 Polyester production

Polyester is one of the most widely produced synthetic polymers, primarily known for its use in textile fibres and plastic packaging. The global textile industry, and in turn the polyester industry continues to grow year on year with a global increase of 7% in fibre production from 116 million tonnes in 2022 to 124 million tonnes the following year (Textile exchange, 2024). Current estimates suggest that this demand for further growth is set to continue to increase as seen in the historic and future growth numbers in Figure 9.

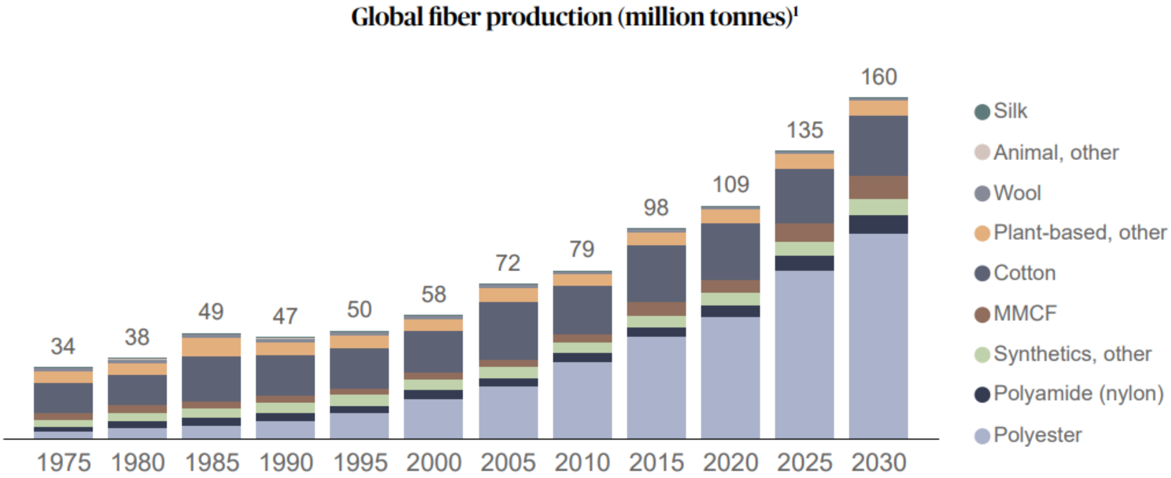

Figure 9 provides global fibre production data spanning 65 years (Textile exchange, 2024).

With it being noted that even within the space of a year from the textile exchange's 2023 report the estimated production for 2030 has been revised upwards from 147 million tonnes to 160 million tonnes in the most recent report (Pakkanen, V. 2024).

Amid rising environmental concerns based on the fact that the polyester industry still relies heavily on fossil fuels, there is increasing momentum to shift the sector toward more sustainable alternatives and therefore reduce the industries emissions (Paul, R. & Gries, T. 2024). Fossil fuel-based fibres accounted for roughly 60% of the global production in 2023 alone (Textile exchange, 2024). These include recycled, bio-based, and CO_2-derived polyester products, each offering a viable route to lowering the industry's ecological impact. While these greener options currently represent a small share of the market, ongoing technological innovation and growing demand for sustainable solutions are expected to accelerate their adoption.

This section will follow the MOOC course's intended layout by summarising the work done by Pakkanen, first providing an overview to the polyester production and the industries environmental impacts, then exploring the main methods of polyester manufacturing, which include fossil, bio and CO_2 based production. Although the general process of each production method remains the same, updated data and figures from 2024 and 2025 have been used in place of older data.

3.1 Polyester production and environmental impact

Since the middle of the 2000's, polyester has accounted for the largest share in global fibre production having overtaken that of cotton, which held the position since the commercialisation of the textile industry in the 18th century (Textile exchange, 2024). Major driving factor for this expansion in production is a combination of rapidly developing fashion trends, commonly known as 'fast fashion', and increases in disposable income following rises in living standards (Filho. et al, 2022). With the forecast growth of the global population expected to continue to increase to 10,3 billion people by the 2080's, along with current trends in the textile industry, the demand is only set to increase (United Nations, 2025).

The main problem that occurs is the environmental impact that the textile and specifically the polyester industry has given that it still relies heavily on petrochemicals such as crude oil as a feedstock. Synthetic materials accounting for the vast majority of emissions the industry produces as seen in Figure 10.

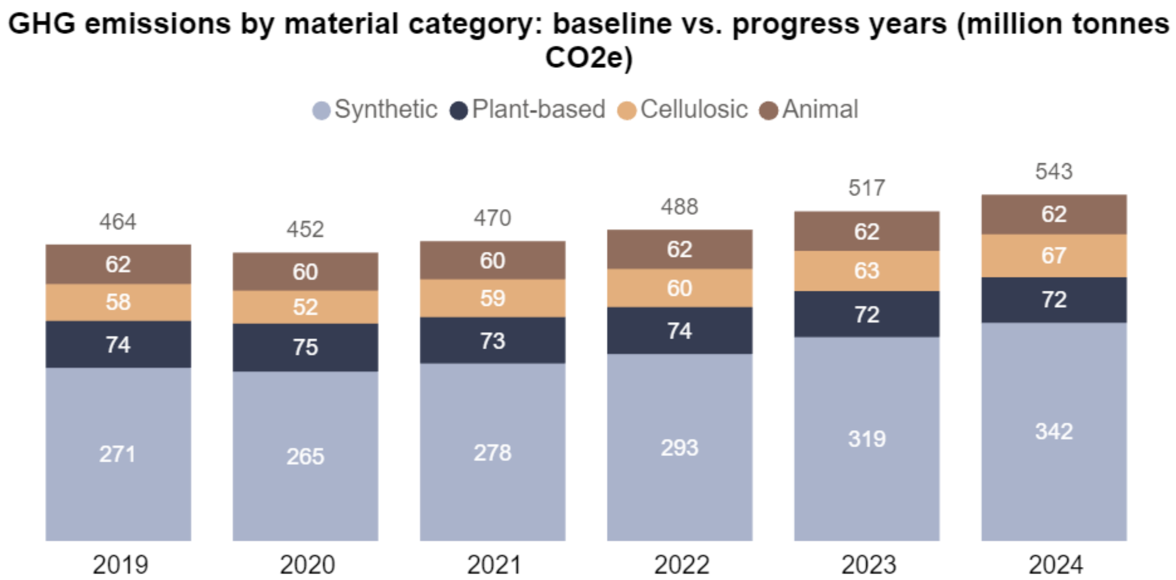

Figure 10, Greenhouse Gas Emissions (GHG) based on fibre category and year (Textile exchange, 2023).

These figures suggest an almost stagnant level of emissions for both plant and animal fibres while cellulosic fibres see a gradual growth and synthetics continues to see large levels of growth in recent years. The only exception for this is in 2020 which saw an overall decrease in emissions, but this can be attributed to a global downturn in production and consumption due to the Covid-19 virus and subsequent global mitigation efforts.

The textile and clothing industry alone is responsible for roughly 10% of global greenhouse gas emissions (GHG) (Khamisani, & Mattila, 2023). This comes from a combination of factors all contributing to the industry's emissions, those being energy and manufacturing process, feedstock, transportation and waste.

The textile industry requires energy intensive processes in order to manufacture textile fibres. Synthetic fibres requiring on average 20kWh of energy per kilogram more than organic fibres such as cotton, standing at 35kWh compared to 15 kWh (Filho, et al. 2022). This equates to roughly 27,2 kilograms of CO_2 equivalents per kilogram of polyester produced, reaching up to 35,7 kilograms of CO_2 equivalents per kilogram of acrylic, which is another synthetic fibre commonly used in garment production. This is compared to 22 kilograms of CO_2 equivalents per kilogram of cotton and only 14,9 kilograms of CO_2 equivalents per kilogram of silk (Sovbetov, 2025). This clear disparity between natural and synthetic fibre energy consumption and resulting emissions is further exacerbated by the use of non-renewable energy as well as a lack of recycling and an ever-increasing demand for new garments.

As already stated, the vast majority of polyesters are still produced using the traditional method in which petroleum is the main raw material. This is a major factor when looking at the overall lifetime emissions of petroleum, from the extraction methods that result in releases of GHGs such as methane (CH_4) and carbon dioxide (CO_2) due to leaks from wells and pipes but also from flaring excess natural gas during extraction along with emissions during transportation and refining which are both dominated by the further use of fossil fuels (Burnham, et al, 2011). Transportation of synthetic fibres accounting for 83% of the total carbon footprint of the global fibre trade, while natural fibres only accounting for 17% (Sovbetov, 2025). These differences in figures can somewhat be justified by the difference in volume of each product being transported along with the distance transported, where synthetic fibres typically require greater volumes and further distances.

Waste produced during the production of fibres along with byproducts are another contributor to the textile industry's environmental impact. Globally, the textile industry generates approximately 92 million tonnes of waste each year. Without substantial intervention and systemic changes, this figure is projected to escalate to 134 million tonnes by 2030 (Business Waste. 2024). With some estimates for 2024 reaching as high as 124 million tonnes of clothes being discarded, which already outpaces the predicted 2030 level (Sajdeh, et al, 2025). The majority of which will end up on landfill sites.

Another factor is the water consumption of the industry. Alone it produces 20% of the global clean water pollution each year. With a single t shirt made from cotton requiring up to 2700 litres of water to produce. This is particularly noteworthy given that 25% of the global population suffers from water security problems (Van Woensel & Lipp, 2020). The use of dyes as well as the release of microplastics during the production and washing phases is another major problem, with a single laundry load worth of polyester clothing able to release some 700,000 microfibre plastics into wastewater systems (Šajn, 2019). This in combination with the high turnover rate of new garments only results in the continued pollution of water systems given that the majority of these emissions of micro plastics and dyes occur at the start of the garments life.

The decarbonisation of the energy industry, improved water conservation and usage techniques in conjunction with both national and international guidelines and regulations, such as the EU's strategy for sustainable and circular textiles, to mitigate large volumes of clothing going to landfill can help elevate the environment impact of the textile industry in its current form (European Commission, 2023; Khamisani. & Mattila, 2023). However, there is still a long way to go in eliminating the industries emissions.

3.2 Fossil-based polyester production

Fossil-based polyester, commonly known as traditional polyester is one of the most dominant types of polyester, specifically in the polyethylene terephthalate (PET) configuration (Nisticò, 2020). As the name suggests, the main carbon sources are obtained from fossil fuels such as crude oil and natural gas. The process of polyester production starts with typically the distillation of the crude oil in order to break down the long hydrocarbon chains into more usable forms those being, ethylene glycol (EG) and terephthalic acid (TPA). These then both undergo polymerisation, in which the monomers form together using ester bonds to produce longer chains of molecules known as polymers. Followed by one of two common commercial processes, direct esterification and transesterification. Direct esterification happens between a carboxylic acid and an alcohol to form the ester bis(2-hydroxyethyl) terephthalate (BHET) and water, in this case the TPA is the acid, and the EG is the alcohol. Transesterification is the exchange of the alkoxy group of an ester with another alcohol. Where DMT is the ester and EG is the alcohol. This reaction results in the creation of BHET and methanol as a byproduct that can be removed. Direct esterification typically requires higher temperatures than that of transesterification, though transesterification requires the use of a catalyst for the reaction. This is then followed by polycondensation resulting in the production of PET (Thomas, et al., 2019). The production of PET, from traditional feedstock and the alternative route of using captured CO_2 is visualised in Figure 11.

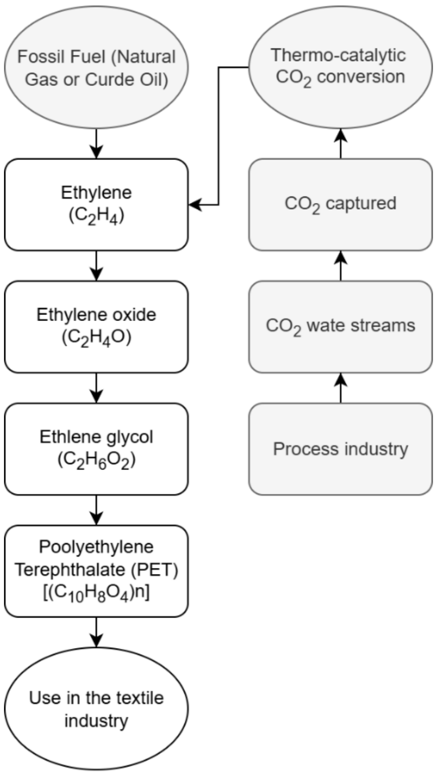

Figure 11, Production of PET via fossil fuel and captured carbon.

To produce PET in a useable form, it typically undergoes one of four manufacturing methods each producing a slightly different fibre with differing usages and properties. The techniques are Filament, Fibrefill, Tow and Staple (Sewport, 2025). Filament technique results in long continuous fibres by extruding the polymers thorough spinnerets. These fibres are then spun together to form yarns which can then be further processed into various fabrics, with its main application in the clothing industry (Textile Gateway, 2025). Fibrefill forms bulk polyester fibres that have good thermal insulating properties and are thus used in padding or filling applications such as in pillows or jackets. Tow fibres are large bundles of continuous filaments that are typically drawn and are able to be used in non-woven applications such as filters. Finally staple fibres are shorter fibres that have similar properties to those of naturally occurring fibres after being spun such as wool or cotton and are thus used in the same applications especially if they are woven fabrics in a polyester-cotton blend. Applications include clothing and non-wovens (Vnpolyfiber, 2022).

There are several different spinning methods available, such as wet spinning for filament and staple fibre shown in Figure 12, electrospinning focusing on non-woven fibres in Figure 13, and gel-spinning producing filament fibres, Figure 14, with melt-spinning being the most typical method to producing both filament and staple PET fibres displayed Figure 15 (Hufenus et al., 2020).

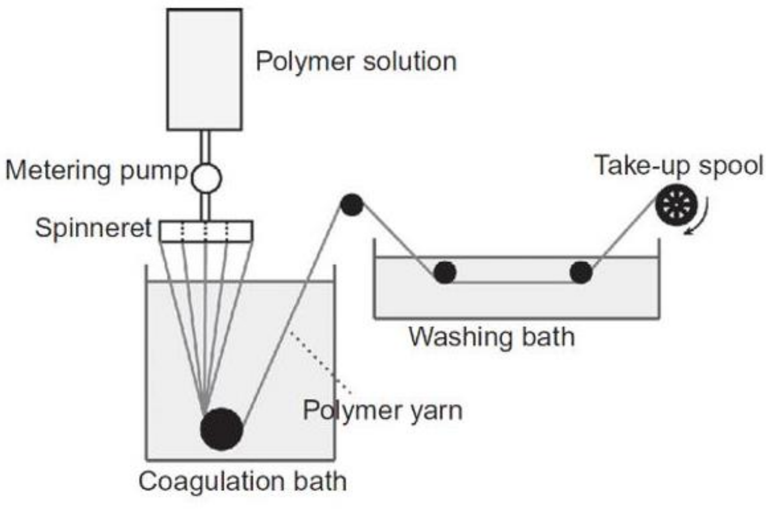

Figure 12, Wet spinning (Vnpolyfiber, 2023)

Wet spinning spins the individual fibres into a yarn passing through a coagulation bath, this process results in a yarn that is resistant to volatile solvents and less likely to lose its colour when heated. It also means that can withstand high temperatures before degradation. examples of polymers produced in this way include acrylics and polyvinyl.

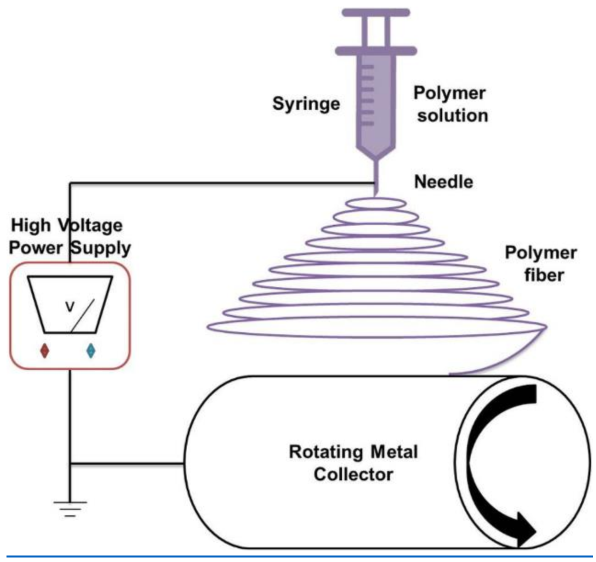

Figure 13, Electrospinning (Muthukrishnan, 2022)

Electrospinning involves spinning the polymer solution while subjecting it to high voltage which results in ultrafine nanofibres. Adjusting the voltage allows the operator to change the structure and properties of the fibres to obtain specific dimensions and characteristics. Currently it is one of the only ways to produce nanofibres on a large scale along with a low cost. Applications are wide ranging from medical applications in dressing to textiles and filters (Muthukrishnan, 2022, Vnpolyfiber, 2023).

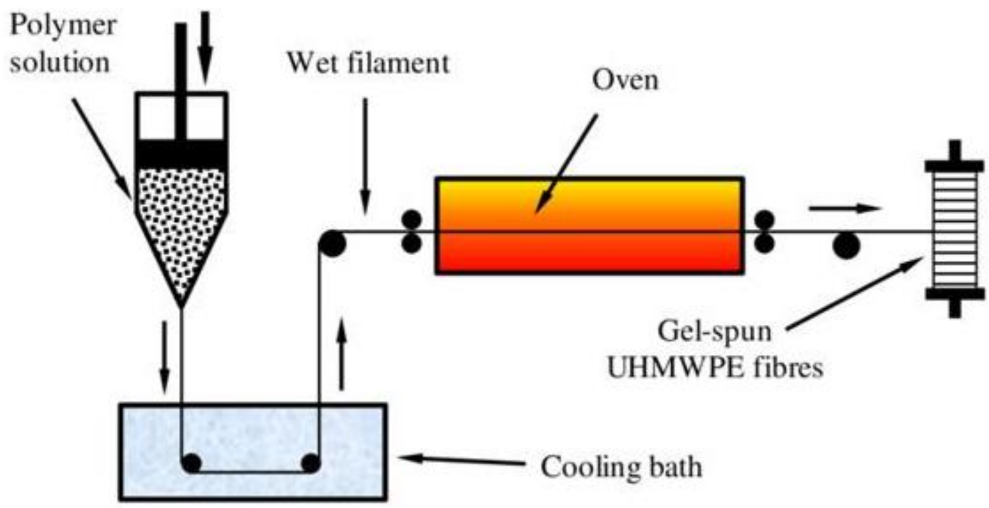

Figure 14, Gel spinning (Vnpolyfiber, 2023)

A newer spinning technology compared to the others; gel spinning involves production fibres from a gel-like polymer solution that is cooled to semi solidify the gel then extracted and dried to remove the solvent while stretching it also. This results in a fibre that has a very high tensile strength and able to withstand thermal deformation. Again, applications vary with ropes and cables along with sports gear being notable uses.

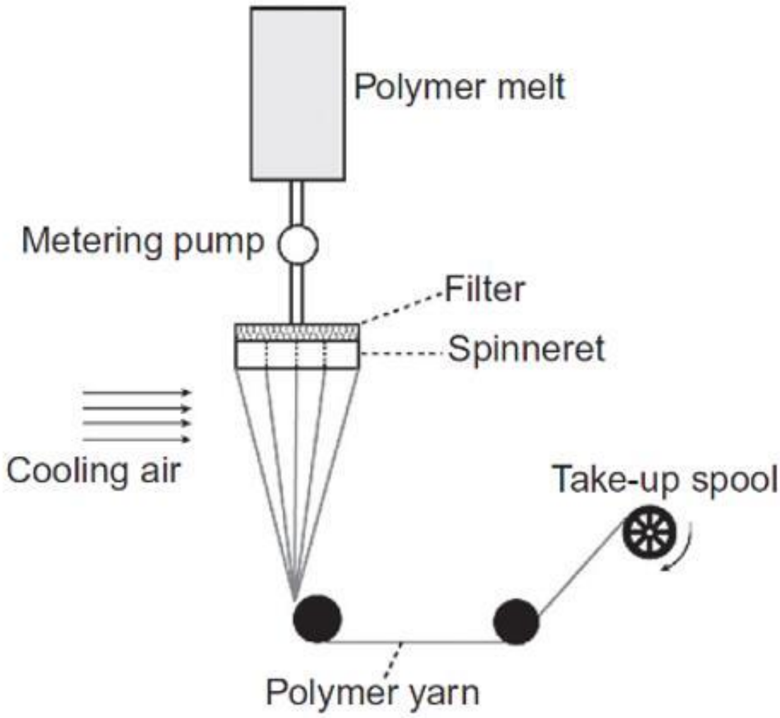

Figure 15, melt spinning (Vnpolyfiber, 2023)

Melt spinning as stated is the most common form of spinning, requiring no solvent baths or precipitants only relying on simple equipment. The polymer solution is extruded and spun by spinnerets into a yarn that is cooled by a constant airflow and stretched in improve its tensile strength before being collected on the spool. Example polymers commonly produced in this way include polyester and nylon. These can then be used in the textile industry as well as for packaging or industrial use.

3.3 Bio-based / Recycled polyester production

With traditional polyester relying so heavily on fossil fuels leads to the realisation of the negative impacts on the environment that the industry has. However, it is not as easy as just removing the production in order to combat this as the market demand still requires to be met. It is therefore for this reason that other methods for producing polyester has emerged over recent years. The two most common alternatives for non-fossil-based virgin polyester are recycled polyester (rPET) and bio polyester (Bio-PET), with the specific aim of eventually replacing the virgin PET in the future.

3.3.1 Bio-based polyester

Bio-based polyester refers to fibres that have been produced using fully or partly materials from biological monomers (Manigandan, et al, 2018). These monomers can come from a variety of sources such as carbohydrates which include starches and sugars and lipids which covers oils and fats among others (Qinan, et al. 2021). Bio polyesters fall into two main categories depending on if they are biodegradable or not even though they are all produced using bio monomers. Examples of commonly available bio polyesters that are biodegradable include polylactic acid (PLA) and polyhydroxyalkanoate (PHA). Examples of non-biodegradable bio polyesters include Bio-PET and polytrimethylene terephthalate (bio-PTT) with Figure 16 offering a visual representation of the various bio-bases polyesters and fossil-based polyesters along with whether or not they are bio-degradable.

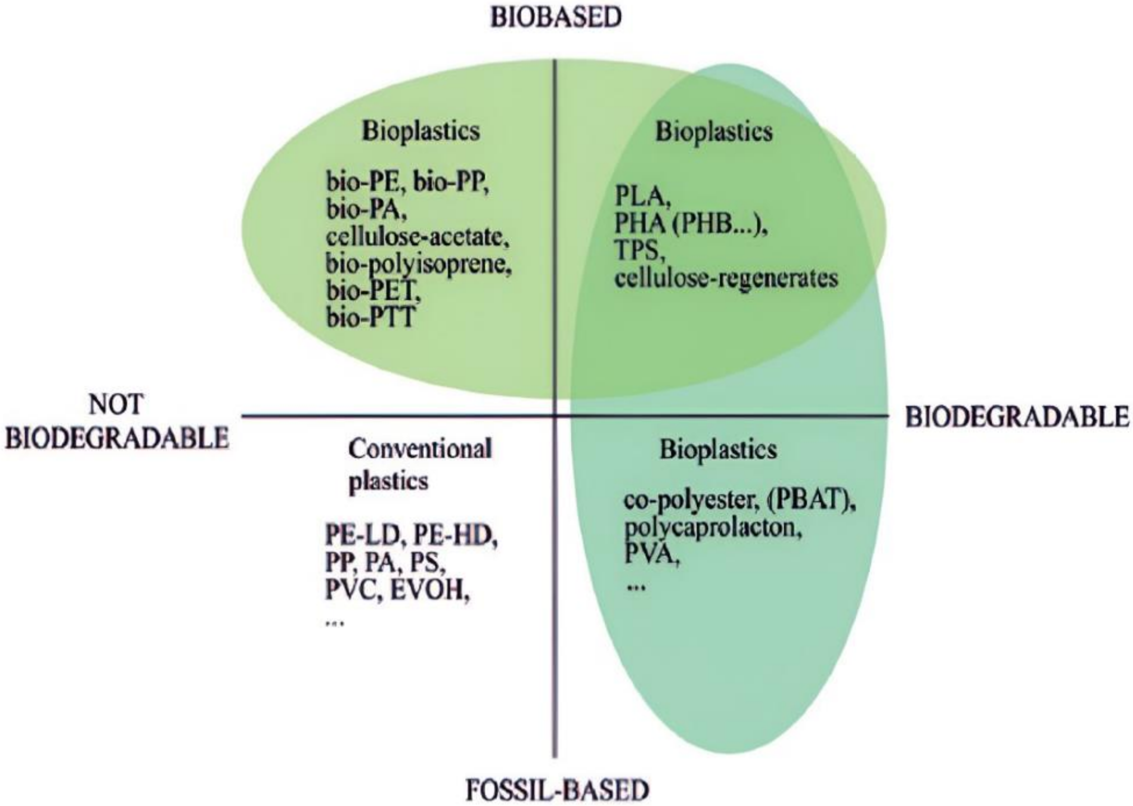

Figure 16, biopolymer class system (Rujnić-Sokele & Pilipović, 2017)

The classification of polyesters in the figure shows that while there are a fair number of different biobased polyesters along with biodegradable polyesters, the number that are both biobased and biodegradable constitutes the smallest category presented. This implies that even if the polyester is advertise as being biobased, there is a larger chance that plastic is nonbiodegradable that biodegradable.

Production of bio-based polyesters varies depending on the feedstock. For example, to produce PLA, a glucose rich source is fermented by microorganisms with the goal of converting the sugars into lactic acid which is excreted into the fermentation broth. This is then purified by way of distillation or evaporation which then undergoes polymerisation to form the plastic. PHA on the other hand uses sugars or lipids to feed microorganisms which ferment the feedstock inside their bodies which is then extracted from the biomass and purified, resulting in the PHA (Alfa Laval, 2024).

Currently biobased polyesters still only account for 0,01% of all polyesters produced in 2023. With only semi biobased materials common on the market, there is room for expansion of the production of bio-PETs in conjunction with the development and adoption of standards for these bio-based materials (Textile exchange, 2024).

3.3.2 Recycled polyester

Recycled polyester (rPET) on the other hand refers to the reprocessing of existing plastic materials, primarily being sourced form PET bottles accounting for 98% of all rPET, into new polyester that can be then other products (Textile exchange, 2024). It is not just polyester that suffers from low recycling levels as illustrated in Figure 17, showing that all major fibre sources suffer from the same problem. Development and innovations are aiming to increase the rPET production from sources such as packaging ocean waste and polyester textiles which is of particular interest given the context of the MOOC course.

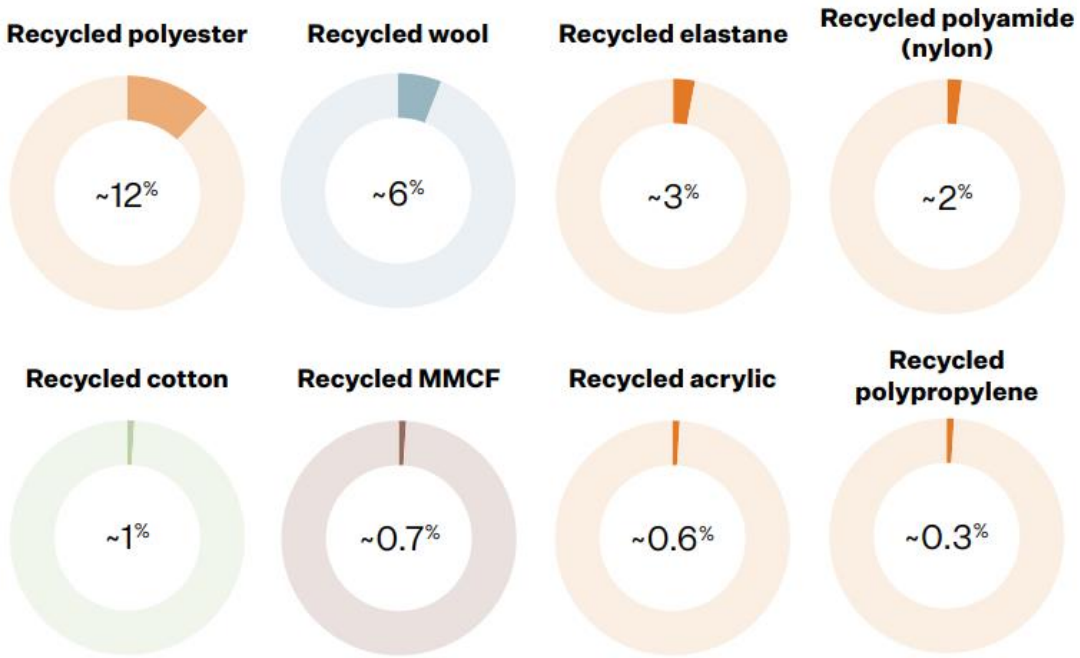

Figure 17, Market share of recycled fibre in 2023 (Textile exchange, 2024).

Currently a tiny percentage of fibres are recycled meaning that there is still a large demand for virgin PET, though shows that there is a large potential for growth in this industry. Between 2022 and 2023, production of rPET increased by 1,3 million tonnes bringing to total to 8,9 million tonnes but due to the overall production of PET increasing in the same period the overall market share of rPET creased by 1,1% to 12,5% of total production (Textile exchange, 2024).

The actual recycling process in split into different recovery processes which are mechanical, thermos-mechanical and chemical (Enking, et al, 2025; Thomas, et al, 2019). Each of these processes results in a different end product. Mechanical involves breaking down the plastics using mechanical presses or cutters in order shred the plastic, it is then softened and formed into chips which are then used for new products with the recovery process reaching the fibre stage (Enking, et al, 2025). Thermo-Mechanical recycling follows a slightly different path, using mechanical presses and heat to reduce the plastic to the polymer stage which allows for it to be re-spun into new products. And finally, chemical which although covers a variety of methods focuses on reducing the plastic down to its polymer or monomer stage with the use of solvents. The solvents dissolve the waste product and depending on the solvent used can target specific fibres to break down allowing for the separation of different fibres. The monomers and polymers are then precipitated out of solution and then are able to be reformed and spun (Enking, et al, 2025).

rPET has many upsides other than just reducing reliance on fossil fuels for the production of polyesters. Some of these benefits includes a reduction in energy demand by the industry, reduced emissions when compared to the GHG emissions when producing traditional polyester, ever reducing costs and the technologies become more mature, the reduction of plastics that end up in landfills or in the oceans and can result in similar properties to those of virgin PET (Enking, et al, 2025; Vnpolyfiber, 2022).

However, that is not to say it is without its drawbacks. rPET is not always possible for certain blends of fibres particularly as chemical processing which is required to separate the different fibres is the most expensive method out of those available, while at the same time requiring more energy to produce than that of organic fibres such as cotton and wool. Also, the quality of rPET produced depends on the type of recycling used with open looped mechanical recycling resulting in poor quality rPET in comparison to that of virgin PET. Water usage along with the release of microplastics that end up in the environment are another issue resulting from the dying and washing processes (Enking, et al, 2025; Vnpolyfiber, 2022).

3.4 CO_2 polyester production

Since the start of the industrial revolution over 260 years ago, the global GHG emissions has been rising year on year from levels of 4,22 billion tonnes of CO_2 eq in 1850 to 53,82 billion tonnes of CO_2 eq in 2023 (Ritchie, et al, 2024). As of the resulting environmental damage and fallout of unregulated emissions, the Paris Climate Agreement was developed with the aim of reducing the levels of carbon-dioxide in the atmosphere in an effort to each net zero by 2050 to meet the 1,5°C target (United Nations, 2023). Strategies that are promoted in order to achieve that goal include among other things, increased utilisation of Carbon Capture, Utilisation and Storage (CCUS) and encouraging the use of circular economy models and low-carbon materials. In relation to this several companies and governmental organisations are now researching ways to use captured carbon as a feedstock for use in industries that are still dominated heavily by non-renewables (Textile exchange, 2024). One such example of these is the Threading-CO_2 project (Aspire2050. 2022).

Different methods for extracting and capturing carbon are currently available with the main technologies being point-source carbon capture and direct air capture (DAC).

Point source carbon capture: Point source carbon capture focuses on collecting CO_2 from the source of emission, such as a power plant of factory as shown in Figure 18. The aim is to prevent those emissions from being released into the atmosphere by way of storage. There are three main categories for this, post combustion, pre-combustion and oxyfuel combustion. Post combustion focuses on removing the CO_2 from the exhaust gas after combustion. Pre-combustion involves heating the fuel without fully combusting it which produces a synthetic gas, the CO_2 is then removed from this before being used as fuel. Finally, oxyfuel involves burning the fuel in pure oxygen instead of air. This process removes the production of other emissions such as sulphur dioxide (SO_2) and nitrogen oxide (NO_x), resulting in CO_2 and water being the main byproducts instead. The water is condensed, and the remaining CO_2 is then stored (BSG, 2025). For the purpose of this thesis, the post combustion technology will be focused on. Prevention of emissions this way is typically done with the use of a solvent-based scrubbers that utilise semipermeable membranes to let the combustion gases in and either water to absorb the CO_2 or an amine solution that reacts with the CO_2 to form a soluble compound. This solvent is then regenerated by the removal of the CO_2 known as stripping using an inert gas which is then compressed for storage or later usage (Carranza-Abaid, et al, 2021).

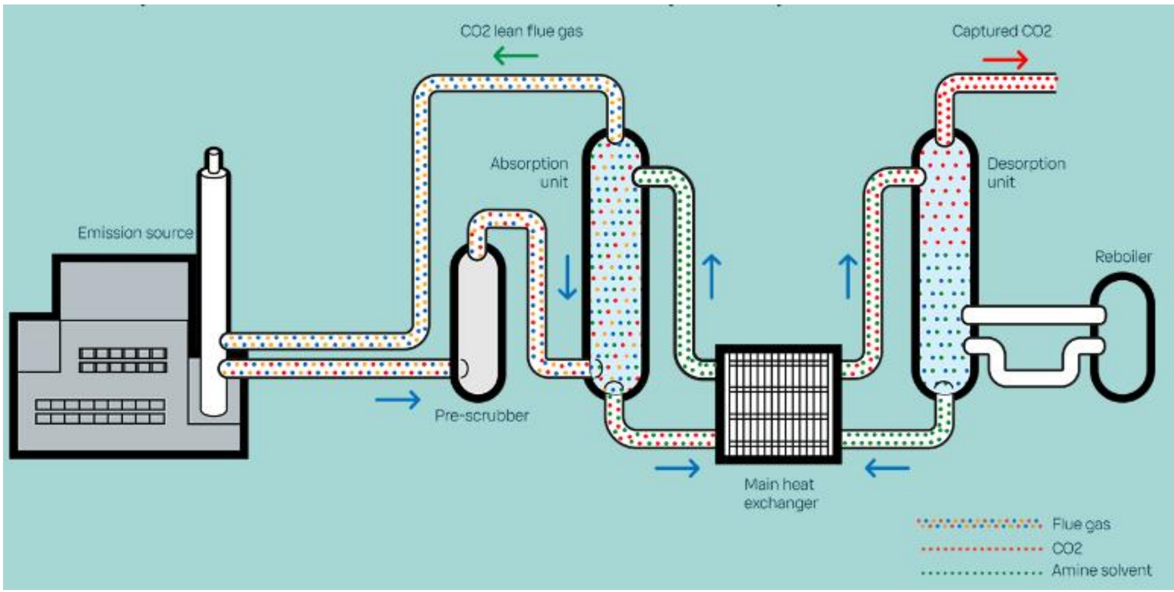

Figure 18, point-source carbon capture process (Vaisala, 2024)

With the added benefit of being widely adopted and able to be retrofitted to existing plants. However, drawbacks include the corrosivity of the solutions used along with their slow degradation over time (Carranza-Abaid, et al, 2021).

DAC systems work in environments with low CO_2 concentrations but require a constant airflow. In a similar way to that of the point source capture units, air passes through the system with the CO_2 reacting with a chemical solution or sorbent which is then regenerated by the removal of the captured carbon which is then stored for usage as shown in Figure 18 (Mihrimah, et al. 2022).

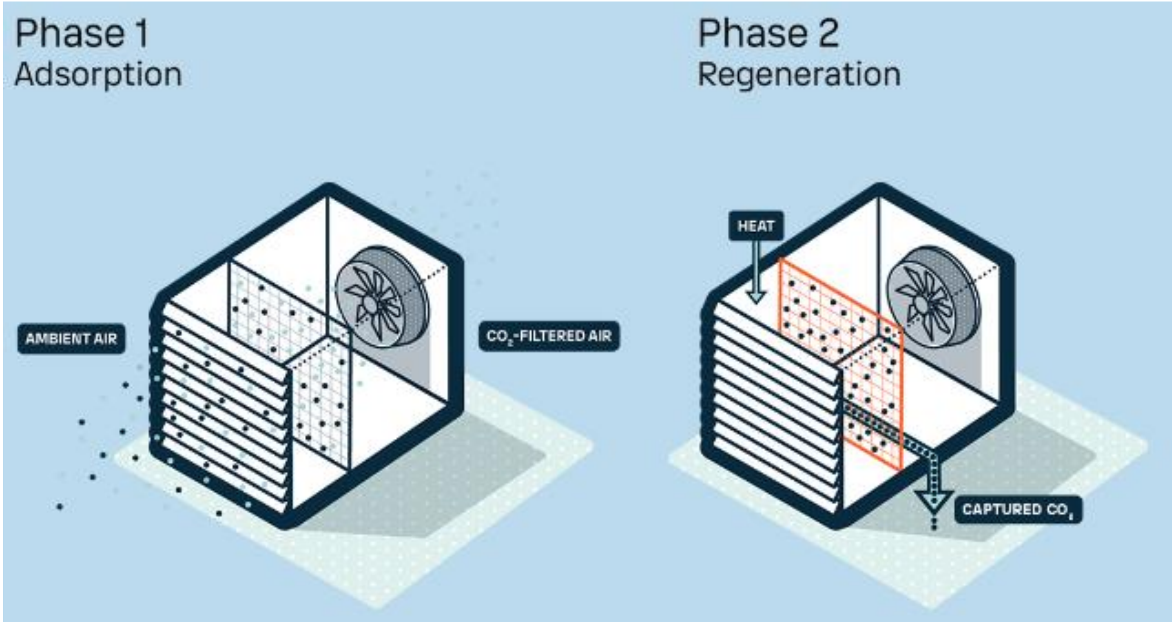

Figure 18, Direct air capture process (DAC) (Vaisala, 2024)

Benefits of this type of system include being location flexible given that it does not need to be near a source of emissions, and ability to be easily scaled up or down. Current challenges faced by DAC systems is its price and technical immaturity compared to other CCUS systems (Sodiq, et al. 2023).

CO_2 polyester refers to the use of CO_2 as the feedstock in the production of polyester, replacing the need for an alternative carbon source such as oil. The ability to transition away from traditional feedstock is particularly advantageous for producers as prices for fossil fuels continue to rise and consumer sentiment shifts towards more renewable sources for their products. To utilise this as a carbon source the captured CO_2 is reacted with ethylene oxide, the resulting reaction produces EG, one of the main compounds needed for polyester production (Damayanti, et al, 2023). Once in this state, the process of producing PET follows that of conventional production (section 3.2) with the polymer solution being spun into fibres and yard which is then used to make the various products.

4 Case study: Sustainable polyester production

The information gathered in Pakkanen's study on the transition from fossil fuels to sustainable alternatives with regards to polyester production was used for the base text for a course (Pakkanen, 2024). Taking on the insights learned in the second chapter of this thesis on the importance of both the preparation of content and assignments, the MOOC course 'Polyester production: Transitioning from fossil fuels to sustainable alternatives' was then created (MOOC LUT Platform, 2025). Within this chapter, the implementation of the features discussed in section 2 will be examined.

4.1 Content presentation

The content of the MOOC was developed, as stated in the introduction, using the research conducted by Pakkanen on the topic of polyester production: transitioning from fossil fuels to sustainable alternatives (Pakkanen, 2024). Using the information gained during the literature review of content preparation in conjunction with the standard LUT template for MOOCs the course was formulated.

Starting with the layout of the course, it follows that of previous LUT MOOCs in which the course starts with general course guidelines, where the topic is introduced, basic background information relating to the bigger picture is laid out, the structure and ILOs are stated and other useful information is provided with regards to the completion of the course and how to access the study credits upon completion of the course. The course guideline tab is then followed by a Frequently Asked Question (FAQ) section with commonly asked questions along with contact information for the responsible teachers of the course in case of further questions or needed clarification. Next a glossary is provided which includes abbreviations that are commonly used throughout the course with which the student can refer to at any time. Based on the template of MOOCs the course is then typically divided into three to four modules with those modules subsequently subdivided into smaller more manageable chunks. The modules used for this course are exhibited in Figure 19.

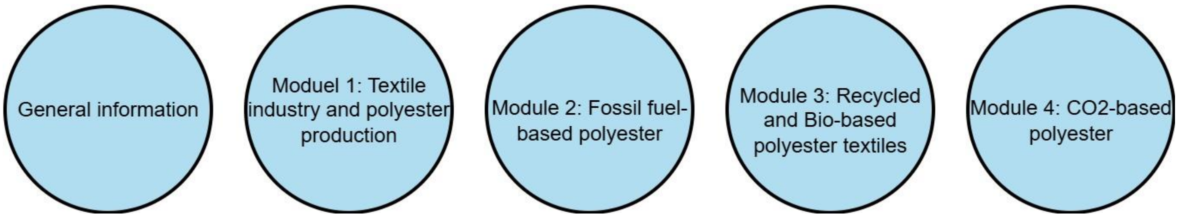

Figure 19 provides the course modules as seen on the MOOC (MOOC LUT Platform, 2025)

Each of these modules has then been divided into and introduction along with three sections to better distribute the workload and compartmentalise the information in an effort to utilise microlearning along with its benefits (Mayer, 2009; Linder, 2007), as stated in earlier chapters of this thesis. The Introduction section provides a brief summary of the previous model as well as a short overview of what the current module will contain, followed by a table which sets out the content layout. An example of this subdivision can be found in Table 1 which shows how *module* 4 is split.

Table 1, *Module* 4: CO_2-based polyester (MOOC LUT Platform, 2025)

Section	Content description
4.1. CO_2 as a carbon source for textile polyester	Environmental benefits of CO_2-based polyester Carbon capture technologies
4.2. From captured CO_2 to CO_2-based EG (ethylene glycol)	Comparison between CO_2-based polyesters and traditionally produced polyester Production and manufacturing process Chemical methods to produce CO_2-based MEG
4.3. CO_2-based polyester: Properties, impacts and scale-up	Qualities and properties of CO_2-based PET Textile focused review of the Paris climate agreement Scalability of sustainable textile alternatives

Both the modules and sections can be accessed in any order, allowing for more flexibility on the learner's behalf in alignment with non-conical navigation (Kim, et al. 2014). This also feeds into the notion of having the course be easily accessible, with on demand learning and not requiring the student to complete the whole course if they decide not to. But in this case, the certificate is not available. A visual guid to this compartmentalisation can be seen in Figure 20 which provides a summarised version of the course layout.

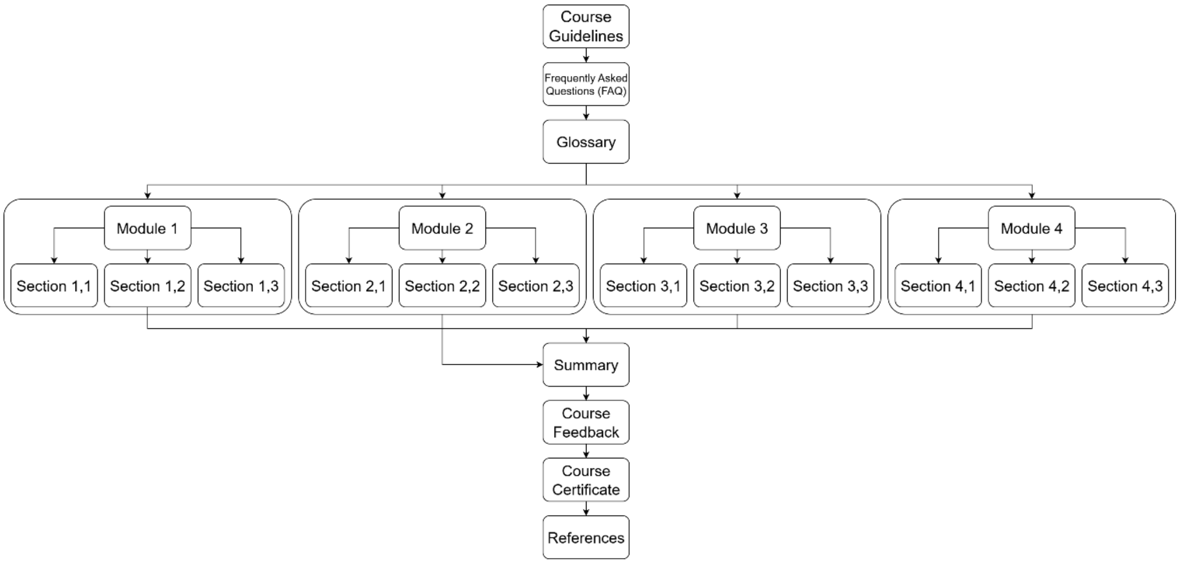

Figure 20, Moodle course layout

As stated, although each of these sections are encompassed by the overall module, they are accessible in any order and do not require the previous section to be completed to progress. Each model's final assessment does need all of its corresponding section assignments to be completed in order to be able to take the assessment. Only after all four general assignments have been completed is the course feedback form available. The course certificate is then provided after the feedback form has been submitted.

Multimedia: Various multimedia resources were deployed throughout the course to both increase the level of understanding and improve the retention rates by breaking up bodies of text with visual aids (Guan, et al, 2018). These included, graphs, figures with bite size information, videos, flowcharts and formulas, with examples shown in Figures 21, 22, 23 and 24.

Figure 21, example of figures with bite size information (MOOC LUT Platform, 2025).

This Figure is used in module 1,1 as a summary of innovation and the main actions being undertaken by the textile industry as discussed in the chapter.

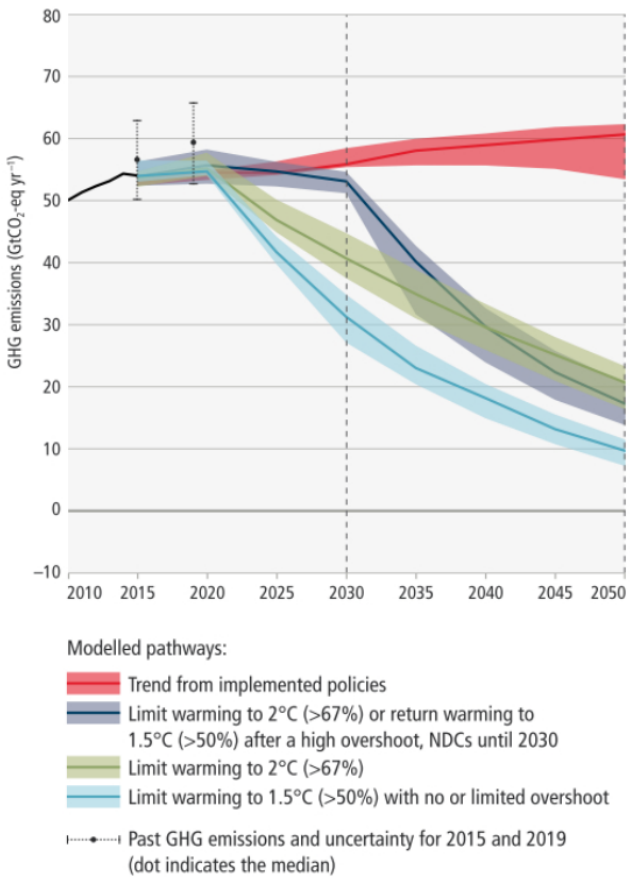

Figure 22 example of a graph used in the MOOC (MOOC LUT Platform, 2025).

This graph, used in section '4,3 CO_2-based polyester: Properties, impacts and scale-up' is aimed at providing a visual representation of different GHG emission scenarios outlined by the Paris climate Change Agreement which is explained in the section.

Figure 23, a video link provided on the course page (MOOC LUT Platform, 2025).

The life cycle of a t-shirt video in section 4,3, although in the '+info' area, provides an option for the learner to undertake further reading and learn extra information relating to the role of the textile sector in climate change.

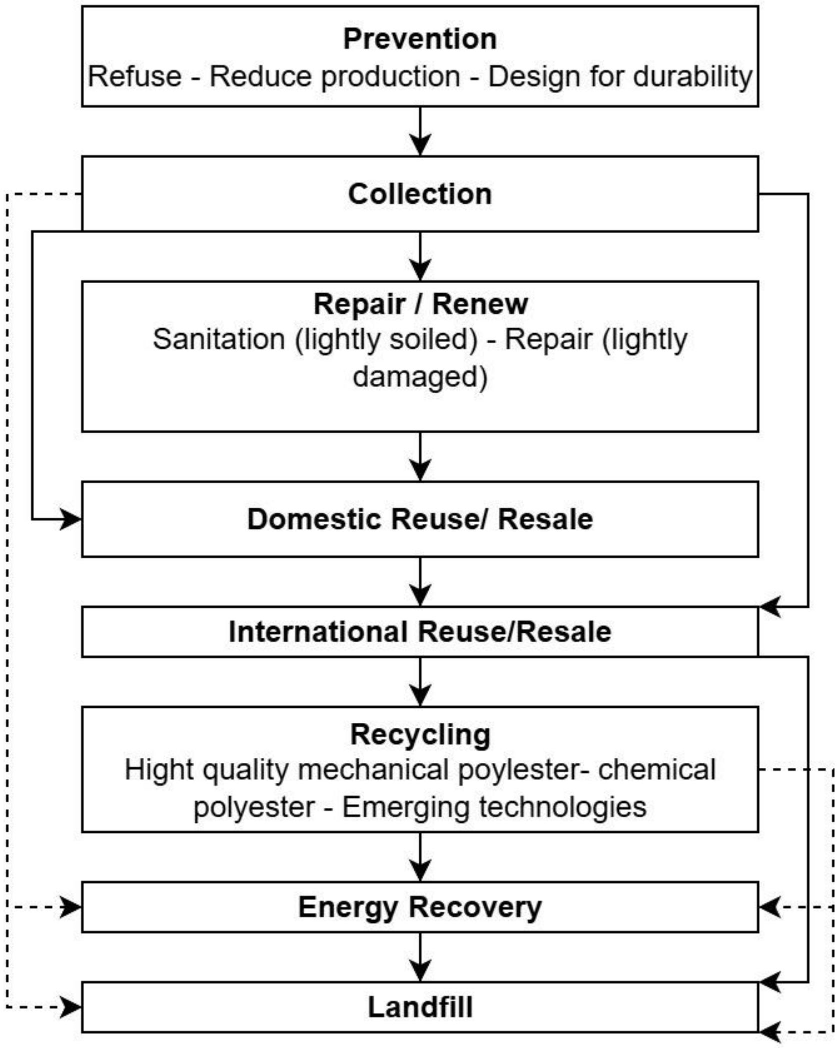

Figure 24, a flow chart of sustainable PET waste management hierarchy (MOOC LUT Platform, 2025).

This flow chart that is used in section '3.1. Recycled polyester textiles' aims to solidify and visualise information provided in text above the figure in the course, along with offering a comparison to the previous part of the section in which the Life Cycle Assessment (LCA) for the textile industry was Described.

Effort was taken in the selection of the media to ensure that it remained relevant to the course as well as the module it is contained in with the goal of providing necessary links between newly learnt information and prior knowledge (Bartoletti, 2016). The variety of media was also chosen in an effort to stimulate both the visual and audio senses to better enhance information retention (Mayer, 2024). Zhang's idea of further compartmentalising videos into smaller clips within the video was not required as the videos employed by this course were deemed short enough to be watch in one go, along with the fact that there is no long form video used on the course such as a full lecture (Zhang, et al. 2016).

Short paragraph: The use of short paragraphs was widely employed throughout all the section as seen in Figure 25. Both to break up the text into more manageable pieces and aid in the visual appeal of the course but to also improve information retention and reduce cognitive overload as mentioned in earlier sections (Sweller, 1988). Along with it, *additional information* was employed that was not required for the course but was nevertheless provided in multiple sections (Son, & Goldstone, 2008). This extra information provided background information on subjects mentioned within the section as well as references for further reading if the learner so wished to explore them more.

[Energy-intensive industry] Textile manufacturing is often an energy-intensive process, especially with synthetic fibers. Polyester is estimated to consume 35 kWh of energy for every kilogram of fiber produced, while cotton requires only 15 kWh/kg.

Another energy issue is linked to the lack of recycling, as significant amounts of textile products end up as waste, increasing the amount of energy used per product (Filho et al., 2022).

[Fossil-based processing] Traditional polyester products use petroleum as their main raw material. In addition, the oil extraction process requires chemicals that are often spilled, contaminating the surrounding soil.

There are other issues related to fossil sources. For example, textile fibers are often produced using fossil fuel energy sources (Sohel, Pichandi, Moorthy, Bhattacharyya, Parveen, Fangueiro, 2015). Furthermore, due to its decentralized nature, polyester production requires different modes of transportation that mainly use fossil fuels, which causes additional air pollution (Palacios-Mateo, van der Meer, Seide, 2021).

Figure 25, Use of short paragraphs in MOOC (MOOC LUT Platform, 2025)

Story telling: Although story telling in the traditional sense for example the one deployed by Johnston was not used, there was an effort to make each section flow into each other with a clear start and end to both the overall course and each of the individual modules through the use of introduction sections and general assignments where the information that was provided throughout the section was consolidated as shown through the layout in Figures 19 and 20 (Johnston, et al. 2016). Through this logical approach and layout, the benefits that story telling provides in relation to user retention are hopefully harnessed leading to higher completion rates along with improved quality of learning.

4.2 Preparation of assignments

Given the nature of online assignments, particularly those of Large Management Systems (LMS), the goal was to try to provide a meaningful examination of knowledge from the learner which aimed for levels of the Bloom's Taxonomy scale other than just the basic remember and understand levels as presented in Figure 4 (University of Florida, 2020). The aim of assignments was to coincide with the ILO for each module as outlined in the course guidelines as shown in Table 2 in line with the pedagogical technique of constructive alignment (QMUL, 2016). Each of these points were deemed to be key aspects and vital knowledge based on the content of each module and therefore required knowledge. Throughout each module and then at the end of the module, there learning objectives were referred to when generating the tasks and assignments in an effort to ensure the unit flowed from one section to another and that the ILOs were met, this is visualised in Figure 26.

Table 2 is an extract form the MOOC course showing the course Intended Learning Outcomes (ILO) (MOOC LUT Platform, 2025)

Module 1: Textile industry and polyester production	Describe the connection between the textile industry and climate change and the importance of sustainable industrial actions to mitigate climate change Explain the impact of industrial CO_2 waste streams on climate change Evaluate the various types of polyester fibres regarding their structure and usage
Module 2: Fossil fuel-based polyester	Explain the method in which traditional polyester is produced Identify the different spinning techniques used for PET fibre formation Describe the different routes that PET can be synthesised from
Module 3: Recycled and Bio-based polyester textiles	Explain the differences in properties between traditional polyester, bio-based and recycled polyester. Identify the advantages and drawbacks of recycled polyester Describe the various recycling techniques available, including their usages and challenges

Module 1: Textile industry and polyester production	Describe the connection between the textile industry and climate change and the importance of sustainable industrial actions to mitigate climate change Explain the impact of industrial CO_2 waste streams on climate change Evaluate the various types of polyester fibres regarding their structure and usage
Module 4: CO_2-based polyester	Identify carbon capturing technologies and explain their environmental benefits Describe the differences in manufacturing and properties between traditional polyester and CO_2-based polyester Apply the benefits of this technology to existing climate change policies

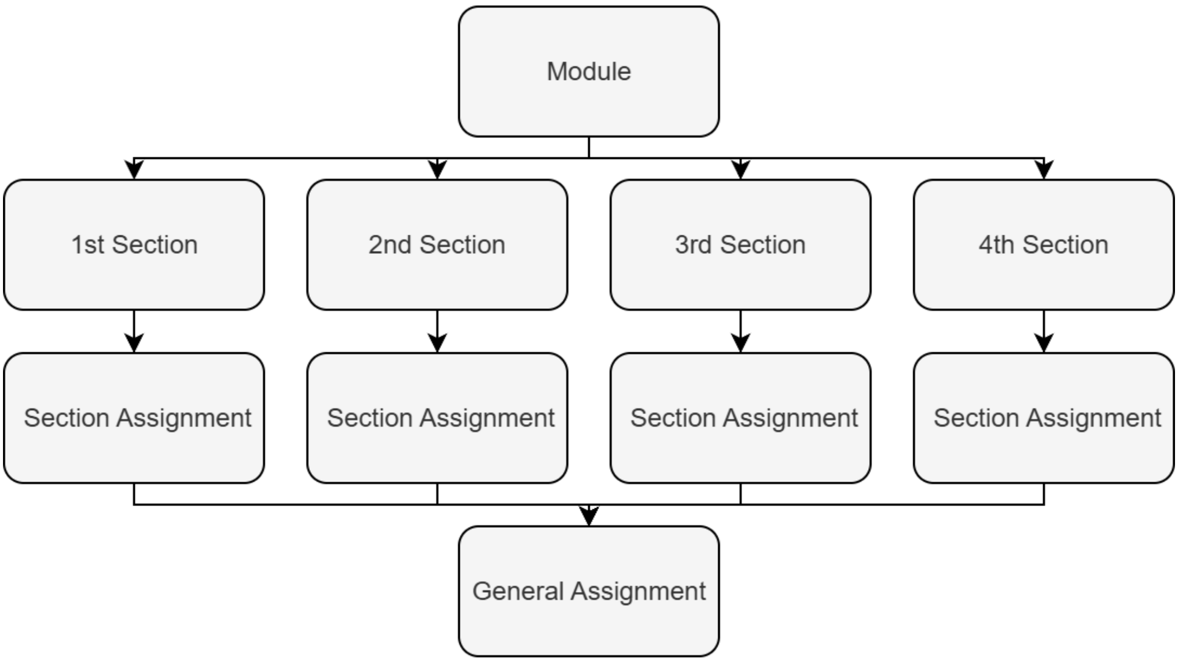

Figure 26, An overview of a modules separation and relating assignments

Question Design: This underlying connection ensured an overall connection throughout the module with regards to each section and assignment. An example of this a question from section 1,3 as shown in Figure 27 and the general assignment for module 1, as show in Figure 28.

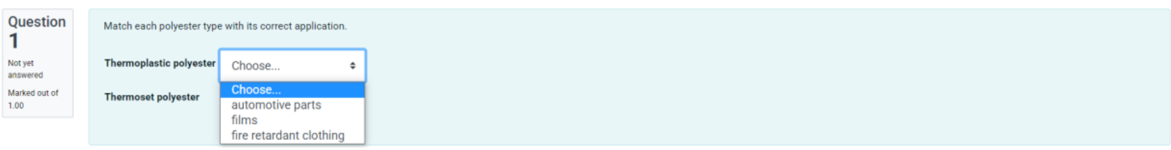

Figure 27 Example question from Assignment (section 1.3) (MOOC LUT Platform, 2025)

From Figure 27 with regards to section 1.3 it links back to the ILO under the point of ‘Evaluate the various types of polyester fibres regarding their structure and usage’ (Table X). In this way it both links to the content presented in the chapter of 1.3 and also the whole module 1. In this specific section (local) task the student selects the drop-down menu and chooses the correct application for that specific type of polyester. A third answer option was added to the two-part question in efforts to encourage thinking and review on behalf of the learner and reduce the chance of them guessing with a fifty percent chance of getting it right. Although this single question does not encompass the whole ILO point, it is just one question form this section of 4 questions.

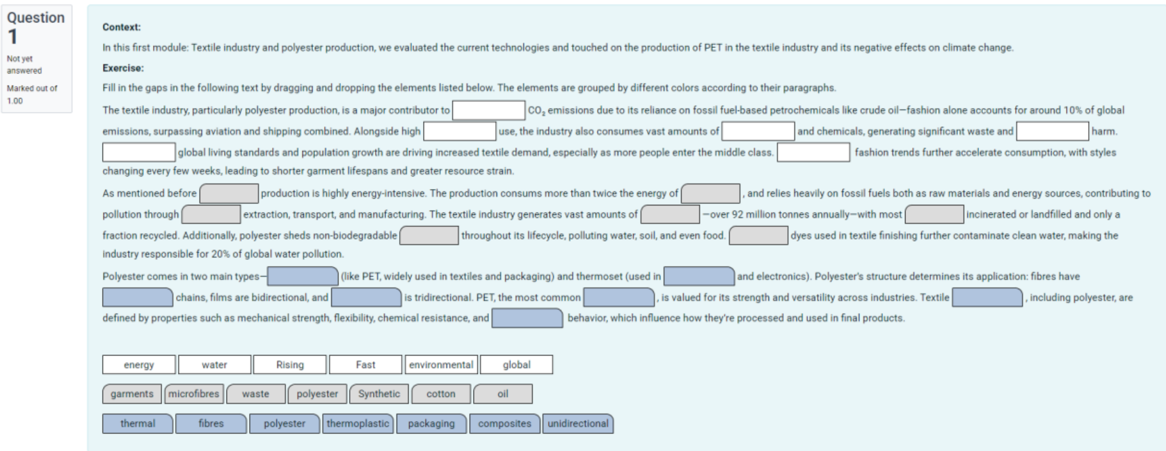

Figure 28 shows the question of General Assignment (module 1) (MOOC LUT Platform, 2025)

The General Assignment of Module 1 was designed with the intention of solidifying knowledge learnt during the module and ensuring all the ILOs were covered. As can be seen in Figure 28, the question is in three parts distinguished by three different answer colours. The goal of this assignment for the student is to drag the corresponding word into the correct place within the sentence to score the points. Each of the three different parts of the assignment correlate to the three different learning objectives for Module 1. In this way, it ensured that at least the basic knowledge has been learned for this module.

Combatting Cheating: Several steps were made in order to reduce the change of students easily cheating. One method was that an effort was made to change the wording of the questions, particularly those that required the learner to fill in blanks or to drop words into sentences in an effort to reduce the possibility that the learner just simply uses the ‘control + find’ option on their device in order to locate the information. This technique was used throughout all assignments in an effort to reduce the change of cheating and require the learner to read the provided information in order to obtain the answer.

Another way was to revise the options for students to review their submitted answers. MOOC has several options for the education providers to choose from which were split into four categories. These are, during the attempt, immediately after the attempt, later while the quiz is still open and after the quiz is closed. Each of these then has options with regards to how and what the learner can do and see after each attempt. These include the attempt itself, whether their answer was correct, their marks for the question, specific feedback (which is automated, and produced when making the question), general feedback (similar to that of specific feedback), the right answer and overall feedback. During the attempt only the attempt can be seen by the student, that is the questions and their answers. To receive a mark the student is required to then submit the quiz. The decision was made to provide everything apart from the right answer immediately after the attempt to prevent the submission of random answers just to obtain the correct ones, that can then be resubmitted. In a similar fashion, for the option of ‘later while the quiz is still open’ only the marks and overall feedback will be visible to prevent the learners from having multiple tabs open of their previous attempts with which to brute force answers given the unlimited attempts. As the quizzes are set up so that they will never close, the options for after the quiz is closed is irrelevant in this case.

A major topic during the literature review of the preparation of assignments was the need to combat the wrong use of AI. Though the lack of essay questions reduces the change of automatically generated text being submitted by learners claiming to be original work is reduced. It does not however, prevent them from providing a LLM with the current questions particularly given that they are more closed questions.

Variety: A different method that was used was to utilise third party data. Meaning that the learner needed to visit specific websites, provided to them both in the course material and the quiz as seen in Figure 29. The student would then need to navigate the website to find the required data. This was also done in an effort to promote further reading and research around the topic.

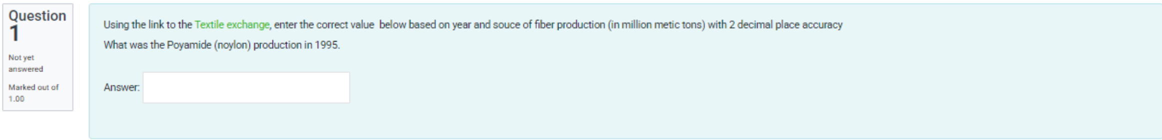

Figure 29 is an example of where a link was needed to obtain the answer to a quiz question. (MOOC LUT Platform, 2025)

Aiming to avoid what Bali noted as a major problem in the LMS community, that being of the heavy reliance on the two lower levels of the Bloons Taxonomy, became somewhat of a problem due to how the course was required to operate (Bali, 2014). The course is intended to operate somewhat independent, that is without the need for an administrator or teacher to constantly be reviewing the submissions of learners and that all assignments and grading be carried out automatically by predetermined answers. However, this lack of intentional and regular interaction between the course provider and the users is something that was highlighted as a particular issue given the nature of online courses (Balalle & Pannilage, 2025). This then resulted in the foregone conclusion that essay questions would have to be omitted from this course due to the nature of needing someone to read said essay in order for it to receive a grade, which goes against the requirement of the course being self-sustaining. Likewise, peer to peer reviews of questions, although they could provide a gate way into which essay questions could be allowed, still would require some level of overview by the administrator to ensure that the reviewers were following, for example, the grading rubric as suggested earlier (Naudu & Sevnarayan, 2023; Ibarra-Sáiz et al, 2020).

This lack of higher levels of cognitive thinking in terms of Bloom’s taxonomy, again relates back to the points made earlier in this paper, referring to the validity of the course in an academic setting particularly when compared to a more traditional in person classes which would provide the same academic accreditation (Admiraal, W. & et al, 2015; Currie, G. & et al, 2023).

Feedback: Following the advice by Hattie, as well as common practices of LUT MOOC courses, a course feedback form was added to the end of the course which is only accessible after the completion of all the prior quizzes and assignments (Hattie, J. & Timperley, H. 2007). This was done in an effort to increase the validity of the feedback, ensuring that feedback in not provided before the course is over and thus skew the results of the overall data. However, Hattie’s three questions were not utilised, instead the feedback form is more intended to gathering insight as to the construction of the course, the student's satisfaction with the course and gauge if they felt like they had learnt something rather than asking the 'where to next' questions. This is a standardised feedback form in multiple MOOCs provided by the university. In the future, Hattie's questions could be incorporated to improve reflection.

5 Learning Management Systems (LMS)

Throughout the earlier chapters the issues and challenges that occur with the advent of the AI age has been looked at with several problems acknowledged, along with the expectation of the technology only increasing its impact on the educational sector as time progresses and models become more advanced. However, it is not all doom and gloom with regards to AI and education, quite the opposite, if utilised correctly and responsibly, AI can enhance the ability to teach as well as to learn by making it easier and more efficient to produce engaging content while providing more personalised and flexible learning (Suryanarayana, et al,.2024). It is for this reason that this chapter will focus on innovative features in Learning Management Systems (LMS) focused on AI applications with various resources analysed that are beneficial for both teacher and student along with the available platforms being compared to one another. Some of the more common LMS platforms include Moodle, Blackboard, Canvas, Open edX and TalentLMS. All offering a slightly different alternative, whether it is focused on the higher education sector or focuses more on the corporate world.

As of current, the Moodle platform is lagging behind its contemporary with regards to its uptake of AI tools in respect to both course providers and learners. Although there is strong interest in this as shown in research by Mutiga, on the deployment of AI in the LMS, its still currently experimental and limited to research purposes on a small scale (Mutiga, 2024).

AI tools can aid in the development of relationships between the student and teacher, something that has been noted as being absent during the Covid-19 pandemic and had a negative impact on student learning (Akram & Li, 2024). This could involve better, more personalised feedback or as simple as more time for questions. This idea was explored by Oliveira et al in their research into LMS, which came about due to the growing demand for electronic-learning (e-learning) in combination with information technology (IT) in an educational setting. They go on to state that the main aim of the LMS is to allow for the automation of administrative tasks such as grading, reports and user records (Oliveira et al, 2016). This form of automation goes hand in hand with contemporary online courses what involve close ended questions which allow for easier automated grading and responses. However, as e-learning and digital learning platforms continue to develop along with technology such as AI, the possibility of enhanced feedback, better automation and the chance to use open-ended questions presents itself. In this chapter, the potential oof these advancements for both the teacher and learner is analysed.

5.1 AI resources for teachers

Teachers and course providers are the backbone of education, be it in a traditional classroom or lecture hall setting or a digital based learning environment, they are still required in order to enable the right level of information based on the stage of understanding to be absorbed by the learner in a meaningful and thought-provoking way. It is this crucial service that educators provide which enable future generations to advance knowledge to deeper levels of understanding and in turn advance society as a whole (Makovec, D. 2018). Oliveira goes on to state that while the level and quality of education between classroom-based learning and that of online learning was not equal, the use of LMS could aid in bringing online learning up to the standard of the more traditional learning environment (Oliveira et al, 2016).

With that in mind, this section will look at how teachers can use LMS in combination with AI, both incorporated in the platform and standalone in an effort to better enhance the learning experience for their pupils and reduce their workload. For the purpose of this study on online course design, higher educational digital learning platforms will be analysed. Some of the most used platforms: Moodle, blackboard, and Open edX will be the focus of this, with each of their features looked at in relation to AI and how they incorporate this advancing technology. It has to be noted that this is only a tiny fraction of the available LMS, with 561 academic LMS in 2021 alone each offering a variation on the digital learning platform format and therefore differences between each of them can vary greatly (Gamage et al, 2022).

5.1.1 Moodle

The first of these digital learning platforms that will be reported on is Moodle (https://moodle.org/). Moodle is one of the worlds largest LMS platforms with over 487 million registered users and over 53 million courses (Moodle Statistics, 2025). Moodle offers a vast array of differing subject courses in a free and open-source platform. With learning tools such as quizzes, videos and workshops being widely used throughout the platform (Gamage et al, 2022). With the role of AI continually growing in the education sector, Moodle has subsequently followed suit with the implementation of AI on its platform following updates 4.5 and 5.0. The site provide set out guidelines for how it aims to utilise AI to benefit learning under the title of AI principles. These principles include human centred AI, transparency, configurability, data protection, equality, ethical practices and education. These focuses are aimed at increasing efficiency and safety, ensuring clarity with relation to what is human and AI, providing booth learners and teachers with the choice to use AI, reducing discrimination while increasing the accessibility of the education, and supporting the use of ethical AI globally (Moodle’s AI principles, 2025).

Following the Moodle LMS 4.5 update, the website has an inbuild subsystem that allows for the integration of AI models through the use of application programming interfaces (API) which connect to multiple LLMs which include OpenAI, Azure and Ollama along with others. This decision to incorporate multiple LLMs was done in an effort to increase variability of tools as well as reducing reliance on one single model, while also improving the inherent flow of course design (Moodle LMS 4.5, 2024). Within the courses administration tab that run on the Moodle 5.0 version, the various LLMs can also be toggled on and off, as well as which AI tasks students can access within the website such as text generation or summarisation, depending on which the course creator prefers. Moodle also provides information on each course participants usage of AI including the action requested, the number of prompts and the length of the response (Moodle 5.0, 2025).

According to the official website, Moodle’s subsequent new AI content editor improves content preparation with the ability to automatically generate both textual and visual materials. This function streamlines the course development process and reduces the cognitive load as well as time spent on the course by the teacher. To ensure transparency and ethical use, AI-generated content is systematically tagged, and a description is automatically attached to images, thereby increasing inclusivity, transparency and accessible learning design which follows the platforms AI principles (Moodle’s AI principles, 2025). Continuing on the topic of transparency, all AI interactions of the students on the course which has enabled the use of AI by the students are logged, enabling the educator to check discrepancies if and when they occur (Moodle LMS 4.5, 2024).

The Moodle platform will continue to develop its AI solutions with both course content and assignment preparation assistance based on their roadmap. Course creators can expect to be able to choose between more LLMs in the future, with the aim of improving performance, privacy and better localisation. Another development is the ability to provide feedback on the AI quality to better improve the system and the models tuning. AI assisted grading is also being developed to provide educators with pre-grading of assignments and suggested feedback for open-ended questions using grading rubrics, it aims to reduce the workload for the course providers while grading but also guaranteeing that it is a human who has the final say when providing students with a grade. Another important development is the future ability to provide the AI with files or URLs with which it will then produce the course based off of the provided information, dramatically reducing the time for material preparation. Finally, quiz questions will be able to be generated automatically based off of the course content which will specifically focus on aligning to the ILOs in line with improved quiz user interface (UI) and user experience (UX) (Moodle Roadmap, 2025).

5.1.2 Blackboard

Another widely popular digital learning platform, particularly in North America, is Blackboard (https://www.anthology.com/). Initially developed to provide online higher education standards, it has now expanded to encompass the whole educational system with providing courses on a vast array of subject at varying levels of education (Bradford et al, 2007). The modern-day Blackboard is comparable to that of Moodle however, there is a fee to use the site for publishing courses unlike Moodle. This fee ranged depending on the size of the institution, required features and course, with prices ranging drastically from 400 US$ for a single course to 9,500 US$ per year (Lizarraga. 2024; Blackboard B2B, 2022). Where Blackboard differs is its uptake on AI, specifically its incorporated ‘AI Design Assistant’, which is much more mature in terms of development than Moodle’s AI abilities.

Similar to Moodle’s AI principles, Blackboard along with their parent company Anthology, have their own version titled Trustworthy AI principles. The first of which is fairness, which minimising harmful biases from the AI that could negatively affect decision-making outcomes. Reliability, requiring validation to ensure that AI outputs are consistent and trustworthy. Human oversight, similar to that of Moodle’s own one, ensuring it is a human that has the ultimate say in decisions such as grading. Transparency and explainability, to help users understand when and how AI systems are used, as well as how to interpret their outputs appropriately. Furthermore, AI systems must be designed with robust safeguards to protect privacy, ensure security, and maintain operational safety along with the associated human values. Finally, clear accountability within and between organizations responsible for the use of AI technologies (Anthology Inc, 2025).

According to the official website, the AI Design Assistant can perform a range of tasks related to the course design and the preparation of material. Given, Blackboard caters to a wide range of educational levels, the AI can be adjusted to ten levels of complexity with regards to the content it generates. These levels range from early primary school, all the way to Advanced PhD level. This level of customisation with relation to the responses provided can both aid in the development of the course as well as reduce the risk of irrelevant information being produced by the LLM.

When starting a new course, the AI can suggest module topics based off of the title of the course and better breakup the course into more manageable chunks while also remaining relevant to the ILO. These auto-generated modules that are provided will then come with a module title, a brief description of the module as well as a picture, all of which is customisable by the content creator.

The AI Design Assistant can also produce rubrics for both the teacher and students, based of off the course content which increases transparency and equality when it comes to grading as well as reducing workload for the teachers. To improve the visual appeal of the course, when selecting in insert images into the course, the AI can both generate images or suggest stock images related to the accompanying content. Following on from the accessibility criteria, the AI can also translate both the course content and task specific outputs into multiple languages allowing the courses content to be accessible to a wider group of learners no matter their language skills (Blackboard AI Design Assistant, 2022).

Another feature of the AI Design Assistant is its ability to aid in assignment production. An example of this is to generate discussion forums, once again these are fully customisable and offer the ability to select the cognitive level inline with Bloom’s Taxonomy. Similarly, journal or diaries are able to be generated. These incorporate a level of imagination or roleplay in relation to the task such as requiring the student to write from the perspective of an expert based off of the courses content. This links in with the earlier section of the preparation of assignments and making them interactive and provoking thoughtful activities rather than only the lower levels of Bloom’s Taxonomy. Further assignments and quiz style questions and question banks can also be automatically produced by the model in relation to both formative and summative assessments.

AI conversations can also be employed throughout the course to stimulate critical thinking and reflection on the topic. And finally, the AI can then take on different personas in each of the conversations, which can aid in learning as explored in the earlier chapters of this thesis with the use of characters and storytelling throughout the course (Blackboard AI Design Assistant, 2022).

5.1.3 Open edX

Open edX (https://openedx.org/), a nonprofit organisation offers open-source software for the development of both Massive Open Online Courses (MOOC) and Small Private Online Courses (SPOCs) (Zabala et al, 2024). The Use of SPOCs are heavily utilised by its sister platform edX, where leading global companies and universities, such as Google and Harvard University can provide courses or whole degrees to fee paying students. Currently in 2025 edX boasts a user base of over 86 million learners with over 4600 online programs (edX, 2025). Open edX structure can be divided into four main categories under its overall umbrella as shown in Figure 30. The LMS with which the actual content of the course is housed, the learner’s portal with which they interact with the course and can review their progress along with any certifications that they have earnt, the administrative portal where progress can be monitored and finally the studio which handles multi-media and authoring tools.

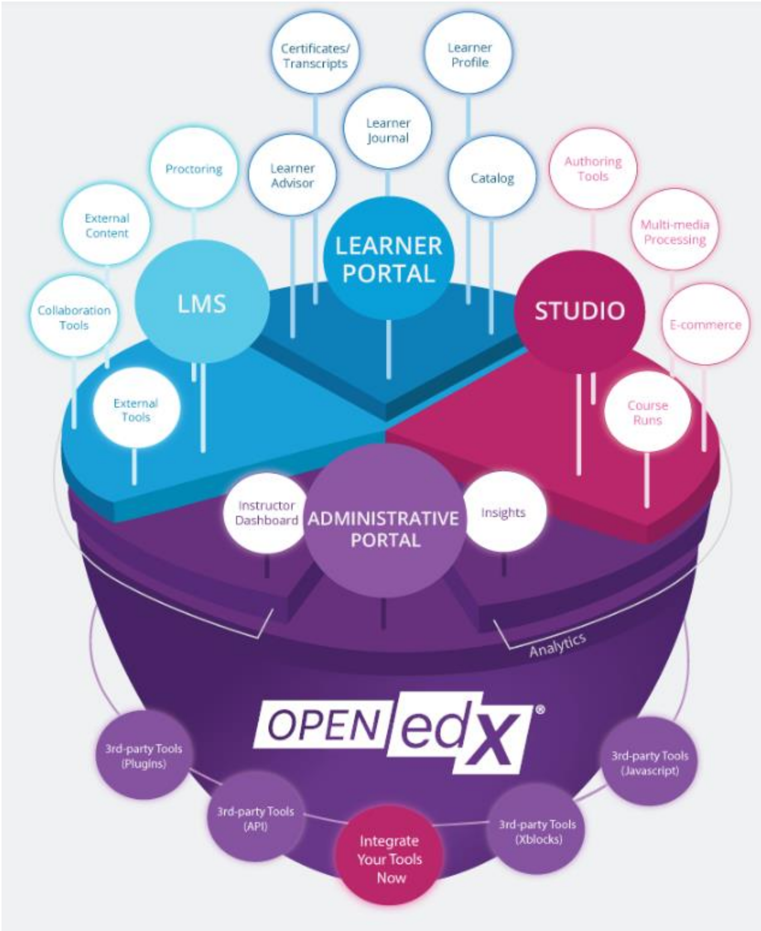

Figure 30 provides a simplified overview of the structure of Open edX

Although Open edX is used by many of the world's leading institutions, the utilisation of AI is somewhat behind that of similar platforms such as blackboard, with Open edX relying heavily on third party software and APIs to access AI tools.

According to the official website, only recently has AI integration on the platform started with the introduction of Owly to the platform. Owly has been pitched as a LLM specifically for LMS unlike more commonly available AI models, with its functions focusing on the four sections that were shown in Figure 30 including content creation with it being able to assist in the generation and design of courses for the LLM section as well as translating the content into various languages, aiding and automating the administrative portal with analytics of students' progress and other key insights being centralised, assisting learners with improves support via guides and instant feedback and finally assist in user authorisation and permissions (Etcheverry 2025).

However, it is also possible to feed the LMS with third party AI generated content which can be formatted to fit the Open edX format as demonstrated by Tadrisi using Python programming language (https://www.python.org/), it still requires the use of external tools unlike other available LMS platforms (Tadrisi, 2024). Currently the public roadmap for future features and development with regards to Open edX is void of any mention of further AI integration, that is not to say there will not be incorporated models in the future how-ever due to the nature of the LMS being open-sourced allowing for continued development (Huthmacher, 2022).

5.1.4 Comparison

Teacher have a wide range of options as to which platform and subsequent tools they use to create and manage their courses. Although, any of the platforms that have been looked at offer similar opportunities in terms of how they utilise AI, they differ slightly.

It is for that reason that a comparison between the LMS's that provide AI tools aimed at educators is provided in Table 3, looking at various different aspects and functions of each of the tools that were discussed throughout the section.

Table 3, comparison between the different teacher focused LMSs

LMS	**AI integration type**	**AI toggle**	**AI analytics/ administrator**	**Student AI report**	**Content generation**	**Plagiarism checker**	**Course development**	**Chat bots**	**Grading assistance**
Moodle	Built in with API support	Yes	Yes	Yes	Yes	No	No	Yes	No
Blackboard	Built in xxx	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Open edX	Integrated with API support	Yes	Yes	Yes	Yes	No	Yes	Yes	No

Although a LMS may have a specific feature, the maturity and ability of that feature can vary dramatically between each platform. Overall, based on the available information, Blackboard is currently the furthest in the deployment of AI features with its inbuilt LLM available to perform multiple actions at various levels of complexity depending on the level of education required from the course and ability to check for cheating among other things. Given that both Moodle and Open edX support APIs, could result in quicker future development with regards to AI features from third party sources. Open edX primarily uses its AI for analytics and teaching assistance while Moodle uses them for content generation.

5.2 AI resources for students

Students on the other hand have different needs when it comes to AI compared to teachers. Rather than using LLMs to generate content or aid in administrative tasks such as grading, students should use AI to aid in understanding, instant guidance or feedback or to improve the quality of their work. This can be existing tools found in the LMS sites like Moodle or Blackboard, or external models such as Microsoft Copilot and ChatGPT. The required task often dictates as to which the student will tent to lean to, with external models offering a greater range of possibilities.

As mentioned before with regards to the preparation of assignments, this comes with the risk of students' misuse of LLMs to do the tasks resulting in the student not learning and retaining the information taught on the course. LLMs can really result in improved quality of work with the use of programs and tools such as Grammarly, Wordtune or QuillBot (Balalle & Pannilage, 2025).

5.2.1 Moodle

As already mentioned, Moodle (https://moodle.com/) facilitates the use of AI within the platform for education providers, but how do the features compare for that of the students. When permitted by the instructors, learners can engage with the inbuilt AI tools to produce content and summarise and simplify textual information provided by the course. The ability for users to harness these AI features is meant to increase transparency and control, particularly as these interactions are logged for the instructors to keep an overview of. With the feature already provided to the student, it also lessens the chance of the learner using other LLMs, where they could be providing prompts that result in excessive aid, be it accidentally or intentionally (Moodle LMS 4.5, 2024). Following the Moodle -5.0 update, new options for the utilisation of AI became available to learners. This feature 'Explain' aids the student by leveraging AI to generate further text based on the information on the course page to further enhance the level of understanding by the student (Moodle 5.0, 2025).

Following on from their current deployment of AI, Moodle is continuing to develop the available features inline with their roadmap points that aim to improve the experience for the learners on the platform. One such example is the usage of the individual communication styles along with specific needs of the users can be used to tailor the replies and interactions with the LMS to better fit the learner. This is done in an effort to improve not only accessibility but also levels of engagement and relevance to the user.

Another feature in development is the use of the inbuilt LMS to be able to condense text from the course into shorter, more concise points, along with clearing up misunderstandings from the students and providing detailed summaries on recent activity on the course such as updates or deadlines. Although a similar feature under the title of 'Recent Activity' already exists to inform the learners of new developments, this enhanced version is aimed at improving engagement levels. A stated feature of these is that the update reports can be delivered to the learners in a variety of ways such as via text, email or as a window when the students next open the course page, further increasing awareness of course updates for the users in a clear manner without them having to search for themselves (Moodle Roadmap, 2025).

5.2.2 AI writing tools

In the ever more integrated world we live in, collaboration between international partners has become second nature. Within the university setting, a vast multitude of different nationalities culminate to form a diverse landscape. However, to make this happen the ability to communicate with one another is key. Medved pointed out, a language barrier can result in challenges in understanding material with regards to both vocabulary and speed at which lectures happen (Medved et al. 2013). The use of online content, especially that is written instead of recorded somewhat mitigates the challenge of speed and in the case of MOOC where learning at one's own pace is emphasised, speed of content should not be counted as a major problem.

A student's ability and willingness to interact, be that in person or online in a foreign language can also hinder their learning (Loderer, et al. 2024). The ability to use the language to a sufficient degree allows for better understanding and conveying of ideas which is particularly useful in an educational setting like a university. The willingness to use the language focuses on challenges such as shyness and other negative emotions when it comes to using a non-native language, this can be a challenge when faced with collaborative work. With Medved proceeding to highlights both reading and writing as key areas where international students struggle in, particularly in grammar and expressions (Medved et al. 2013). This is where AI writing tools come into play.

Tools such as Grammarly, WordTune, QuillBot and Writer, to name a few, are examples of AI applications that are specifically catering to assisting writing. These can be subsequently subdivided into four categories; writing evaluation and corrective feedback tool, writing assistant, paraphrasing tool and machine translator (Alharbi, 2023; Roe et al, 2023).

Writing evaluation and corrective feedback encompasses accuracy and readability of text, covering things such as grammar, spelling, text structure and style. This is done by providing suggestions, explanations and corrections based on the input of the user, and example tool would be Grammarly (Grammarly, 2025). Grammarly can then provide aid in improving the clarity of the work reducing the unnecessary back and forth that can occur when writing. While also adjusting the tone of the writing based on the individual circumstance.

Writing assistant aids in the composing of text aiming to enhance efficiency and effectiveness of text though the use of AI to generate ideas, outline the structure of work or to refine text. An example of this type of writing tool would be that of Notion AI (Notion AI, 2025).

Paraphrasing tools are used mainly to reword existing text while retaining the overall meaning of the original text, a benefit of these is avoiding plagiarism or simplifying complex or technical language. A popular paraphrasing tool is QuillBot (QuillBot, 2025).

Machine Translation, as the name suggests, focuses on converting text from one language into another language while maintaining the meaning and converting expressions and cultural nuances across the language gap. While translation tools have existed for a long time, such as Google translate, they often struggle with the translation of meaning particularly when it comes to idiomatic expressions (Abjalova, Sharipova, 2024). Available programs include DeepL and Microsoft Translator (DeepL, 2025).

5.2.3 Comparison

Students can leverage these devices to both enhance their writing and level of understanding. It has to be noted that there is a fair amount of overlap between each of these tools, even if they are advertised as specifying one aspect. For example, Notion AI can also provide translation services, be a writing assistant and a time manager (Notion AI, 2025).

In a similar fashion to the comparison conducted for the LMS AI tools for teacher (section 5.1.4), a comparison between the AI resources aimed at students will be conducted in Table 4, focusing on the various aspects and functions of those that were analysed.

Table 4 comparison between the different student focused LMSs

AI tool	**Text generator**	**Writing evaluation**	**Corrective feedback**	**Writing assistance**	**Paraphrasing tool**	**Translator**	**Explain / expand**
Moodle	No	Yes	Yes	Yes	No	No	Yes
Grammerly	No	Yes	Yes	Yes	Yes	Yes	No
Wordtune	Yes	Yes	Yes	Yes	Yes	No	No
QuillBot	Yes	Yes	Yes	Yes	Yes	Yes	No
NotionAI	Yes	Yes	Yes	Yes	Yes	No	No
DeepL	No	No	No	No	No	Yes	No

Similarly to the AI resources for teacher, certain features of the AI tools for students are locked behind paywalls and as a result, not all of their features were able to be checked. Also, features in each of them can vary greatly depending on the maturity of said feature even if the basic feature is available. Moodle is not a dedicated writing tool but rather a LMS that offers students AI possibilities, resulting in perhaps not a fair comparison between it and the other AI tools.

Each AI resource has its own strengths which can be valuable to the student given the right circumstances. Having said that, Grammarly currently dominate the student focused AI tools across the board in terms of features and user count with an estimated daily user count of 40 million (Debnath, R. 2025). While QuillBot is not far behind in terms of available tools, its abilities are somewhat behind those of Grammarly (QuillBot, 2025). Where the other tools tend to specialise in certain areas, DeepL is specifically designed for translation and for multilingual learners, Notion AI focuses on idea generation and organisation while Wordtune focuses on fluency and readability. Moodle stands alone in this cohort by its ability to offer structured course specific assistance and being able to explain or expand concepts.

6 Conclusions

The main focus of this thesis was to design a MOOC based on prior research conducted by Vilho Pakkanen on “Polyester production: transitioning from fossil fuels to sustainable alternatives” which was then uploaded to the LUT MOOC platform (Pakkanen, 2024). Improvements based on pedagogical techniques for digital learning platforms were evaluated and implemented for this course structure. A renewal of the research surrounding the polyester production took place to include current data and figures. And finally, comparisons between popular AI tools for LMS and external tools in relation to teachers and students was conducted.

The insight gained during the literature review was implemented in the development of the course material and the course assignments where possible. Research on online courses pointed to several pedagogical techniques to improve the course material. Compartmentalisation, non-conical navigation, multimedia, contextualisation and storytelling were all highlighted by previous research and subsequently leveraged by this course and implemented in the course material. Assignments were then developed by myself, in relation to each modules specific Intended Learning Outcomes (ILO) to both better fit the course and ensure that the learner absorbs the required information.

AI provides both opportunities and hindrances within the academic community particularly in relation to online learning spaces. Several tools and platforms are already available for education providers to utilise for course production, reducing workload through automation and aiding in improving learning materials. Learners can harness AI writing tools to both improve their work and increase levels of understanding of both course materials and task. However, over reliance of AI can lead to inaccurate information being provided if not checked thoroughly and reduces human interaction which is seen as key method to ensure students are absorbing the correct information. It also increases the risk of misuse along with a superficial level of understanding on the learner’s behalf.

Limitations also arose during the preparation of assignments because of the large number of participants that typically participate in the courses along with the limited availability of teachers to be able to grade assignments resulting in the preferred automation of MOOCs in relation to not needing further input from the course provider after publishing the course.

This meant that there were restrictions on what type of assignment could be implemented on the course. These included open ended questions such as essay questions and short form answers, peer reviews and collaborative group works or discussions. These all were highlighted during the literature review as helpful tools in improving the ability for the student to absorb the information in a meaningful way and achieving a higher level on Bloom's Taxonomy scale. Continuing on from this point, the use of closed-ended questions like multiple choice does not combat, at least initially, any possible AI assistance that learners might use. Open questions on the other hand are more beneficial as they can challenge the learner's level of understanding far greater than closed questions can and in turn access the higher levels of learning. However, AI is trained to provide answers in this format and so currently makes Open questions easy targets for cheating.

About the MOOC platform, future developments regarding the implementation of AI tools for the education provider could aid in the reduction of this possibility allowing for the automation of grading open ended questions, thus mitigating the need for the closed questions while also analysing the answers for signs of AI generated text which would then be highlighted for human review. These technologies for automatic essay evaluation and answer evaluation are not easily available as of yet. The utilisation of AI to further improve the ability to produce courses would then bring the platform in line with several other mainstream LMS such as Blackboard and Open edX.

Furthermore, the insights and tools used in the formation of the MOOC can then be transferred onto existing and future courses in order to enhance the quality of education that they provide in terms of provided content as well as the accompanying assessments.

Although course participants feedback in not yet available due to the course not being released at the time of the writing of this paper, further review of suggested improvements and subsequent implementation of the feedback could both improve the quality of the course and the learning experience, thus increasing the validity of the course's accreditation. Further research could then be conducted on the improved course following the feedback suggestions in combination with developments on the MOOC platform with regards to AI tools and how they can contribute to the success of the course and, ultimately, actual student learning.

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