Tiered Assessment for DSP Education: Exploring Students' Motivation and Performance

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Abstract **- This paper presents the Tiered Learning Framework (TLF) for course and assessment design in Digital Signal Processing (DSP) education. TLF divides the learning curve within a course into five levels, encourages students to reflect on which level they are currently at in their learning, and guides them on what they need to do to progress to the next level. Within this framework, students have more control and choice over how much they want to learn and how deeply they engage with the material. A key driver of student adherence to the framework and a mechanism for appropriate feedback is the use of suitable tiered assessments. The TLF was specifically trialled in class settings of various sizes over the past three years, for DSP courses and design projects. Feedback from students indicated that the TLF-based assessment inspired and motivated them to self-assess their understanding of the topic or course they studied and guided their improvement to the next level.**

I. INTRODUCTION

Digital Signal Processing (DSP) education plays a vital role in almost all Electrical and Computer Engineering programs due to its broad range of applications across engineering disciplines. It is particularly essential in emerging and rapidly evolving fields such as machine learning, artificial intelligence (AI), and quantum computing. DSP provides students with the theoretical foundations and practical skills needed to analyse and process digital signals in various forms. As the demand for skilled professionals grows and AI tools become more sophisticated, it is increasingly important to ensure that students are well-equipped with the necessary expertise in DSP. AI-assisted tools, such as intelligent simulation platforms, automated code generation and AI-powered DSP tutors, are now being integrated into DSP education to enhance learning efficiency and deepen conceptual understanding. These tools can personalise feedback, adaptively challenge students and support real-time signal analysis, preparing graduates for the AI-driven engineering landscape ahead [1], [2], [3].

Over the past 40 years, DSP education has evolved from a traditional lecture-based approach to one that integrates digital tools, hands-on hardware laboratory experiences and active learning methods [4], [5], [6], [7], [8], [9], [10], [11]. More recently, the intersection of DSP with emerging fields and tools in artificial intelligence has highlighted the need for innovative pedagogical strategies, particularly in assessment, to ensure students acquire the relevant and in-demand skills [2]. Assessment frameworks are essential for teachers in designing assessments that ensure students develop specific competencies throughout their learning journey while also providing a compelling learning experience. Taxonomies such as Bloom's [12] and SOLO [13] have been widely used to define learning outcomes and guide assessment design. However, tiered assessments have been implemented in various formats and do not always align with any single taxonomy [14], [15], [16], [17].

In universities, grading systems typically use letter grades or numerical scales to assess students' performance in courses. These grades are closely linked to learning outcomes, and assessments are designed to measure the extent to which students achieve them. For example, if a student receives a 'C' grade, it indicates they have met the minimum requirements for passing the course. However, what specific skills the student has developed by the end of the course is often not clearly articulated. The grade merely suggests a general level of understanding rather than indicating what the student is actually capable of doing. Similarly, an 'A' grade signifies outstanding performance and a thorough understanding of the content, yet it still lacks clarity about the tangible skills acquired. In many cases, we focus on outcome-based assessment through grades, rather than on the demonstrable skills students have gained.

To address this gap, we require an assessment framework that incorporates a tiered structure, with each level corresponding to specific DSP skills students are expected to develop. These levels should be directly linked to the grades students receive. Such a system allows students to choose their entry level based on prior knowledge and gradually progress to higher levels of learning. This is the essence of the Tiered Learning Framework (TLF) [18] [19].

II. TIERED LEARNING FRAMEWORK

Tiered teaching, also known as hierarchical teaching, is an approach in which students are grouped based on their skill levels, and lessons are tailored to meet the specific needs of

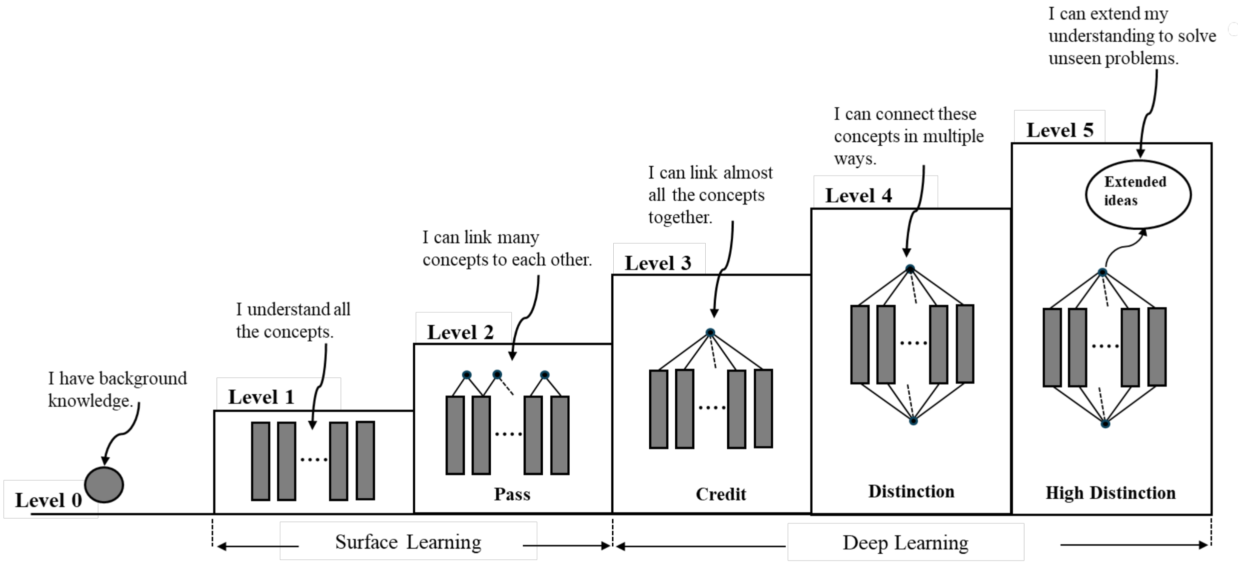

Fig. 1. The Tiered Learning Framework

each group [20]. A single class may consist of multiple such groups. In the context of Digital Signal Processing (DSP) education, hierarchical teaching has been implemented by tailoring content to accommodate the diverse capabilities of students. The study concluded that this approach significantly enhances student motivation and learning outcomes, though it also places higher demands on the teacher's skills and instructional design [20]. In simple terms, learning materials are structured in a tiered format, and assessments are aligned with the tiered content covered in the course [19].

The Tiered Learning Framework outlined in this paper ensures that all students, regardless of their current ability, are taught the same core content, while assessments, such as tutorial questions, mini-projects and final examinations, are structured across four progressive levels. Each level is aligned with specific skills and grade bands. At our university (UNSW, Sydney), once the students have successfully completed an assessment of a course, they are awarded one of five grades, namely, Fail (0-49%), Pass (PS: 50-64%), Credit (CR: 65-74%), Distinction (D: 75-84%) and high Distinction (HD: 85-100%). We have designed the Tiered Learning Framework (TLF) to include these grades to help students understand the different levels (Levels 1 to 5) on the learning curve and what they need to do to progress to the next level. This approach empowers students to have greater control and choice over the depth of their learning, allowing them to explore and deepen their knowledge at their own pace without disadvantaging any student.

The relationship between grades or grade bands and skill acquisition, as embedded in the Tiered Learning Framework is illustrated in Fig. 1. In the undergraduate DSP course at UNSW, the content is structured into six chapters (see Appendix A), each chapter containing multiple concepts. In Fig. 1, each vertical bar represents a single concept within a chapter. For example, if a chapter covers five concepts such as sampling theory, aliasing, discrete-time signals, frequency analysis, and quantisation errors, it is represented by five vertical bars. The background knowledge required for Chapter 1 might come from a Signals and Systems course. Chapter 2 builds on the knowledge from Chapter 1, Chapter 3 builds on Chapters 1 and 2, and so on. The various phases of the TLF for a particular chapter are described below:

TLF (Level 1): At this level, all concepts related to a specific chapter are taught, and students grasp each concept individually without connecting them. Their understanding of the concepts can be evaluated through multiple-choice questions.

TLF (Level 2): At this particular level, students have the ability to establish links between various learned concepts (depicted by vertical bars connected by lines), but not all of them. Once all the assessments for this level are completed, students will have obtained the fundamental knowledge required for the subject matter. A student could get a mark between 55% - 64%, indicating that students possess a basic understanding of the material. However, their knowledge at this stage remains only at surface-level, where they can only connect some of the concepts and still lack some key knowledge required to fully understand the course.

TLF (Levels 3): At this stage, students possess the capacity to establish links between all the concepts learned within a particular chapter (vertical bars are interconnected), indicating an elevated level of understanding of the subject matter. A student could get a mark between 65% - 74%, indicating that students are beginning the development of a profound understanding of the subject matter.

TLF (Level 4): At this stage, students are able to interconnect all the concepts they have learned in multiple ways (illustrated by vertical bars joined at the top and bottom). This demonstrates their deep understanding of the subject, as they can approach and solve problems using different strategies. The achievement range for this level falls between 75% - 84%.

TLF (Level 5): At the highest TLF level, students have the capacity to apply their comprehension of the topic to extend ideas or solve unfamiliar problems using the knowledge they gained from levels 1 to 4. A student could get a mark between 85% - 100%, at this level.

Levels 1 and 2 represent surface learning, while Level 3 marks the transition to deep learning, which continues through Levels 4 and 5. Students are encouraged to build their skills sequentially from Level 1 to Level 5 within each chapter.

III. TLF - BASED ASSESSMENT DESIGN FOR DSP EDUCATION

A. *Motivation for TLF based Assessment in DSP Education*

Diverse Students Cohorts: We teach large undergraduate DSP classes at UNSW, Sydney, typically with 150–300 students from diverse academic backgrounds and varying learning paces. Despite experimenting with various teaching methods, a one-size-fits-all assessment strategy did not effectively address this diversity. Our aim was to ensure that a pass grade reflects meaningful learning, that is, students have acquired the minimum required skills in each chapter and are able to connect and apply most of the key concepts they have learned in that chapter (see Level 2 in Fig. 1)

Improved Engagement and Progression: Traditional approaches often led to surface learning and disengagement. The TLF was designed to motivate students by clearly linking their progression to deeper levels of understanding and each level is linked to specific grade outcomes, providing a strong motivational incentive for students to advance

Structured Skill Development: DSP concepts from basic sampling theory to advanced multirate systems require cumulative understanding. TLF allows students to build their skills sequentially, moving from foundational (Level 1) to advanced (Level 5) competencies.

Student Choice: The framework also allows flexibility - students can choose to move forward to the next level, remain at their current level or revisit a previous one, depending on their confidence and mastery of the topic.

Assessment for Learning: Assessments in the TLF are not just for grading but also guide learning. Each level integrates tutorial tasks, mini-projects and final exams, structured to support reflection, goal-setting and self-paced advancement.

Pedagogical Innovation: TLF evolved from two decades of experimentation with teaching strategies such as flipped classrooms, and project-based learning. It integrates these innovations into a cohesive framework that supports long-term learning outcomes.

By promoting deep learning and sustained engagement, the TLF helps improve knowledge retention which is critical for success in advanced DSP courses and fosters interest in research, leading to final-year projects.

B. *How to Design Tutorials for a Course Using the TLF?*

At UNSW the DSP course is a part of the third-year undergraduate program in the School of Electrical Engineering and Telecommunications and it spans over a term of 10 weeks, involving a total of 60 contact hours. The course structure includes 3 hours of lectures, 1 hour of tutorial and 2 hours of lab per week.

The tutorial questions for each chapter have been designed to align with the TLF framework. These questions are categorised into five levels, and each level assesses students' understanding and ability to connect the concepts learned in the topic. For TLF Level 1, there are typically 5-10 multiple-choice questions that mainly test the students' comprehension of the concepts covered in that topic. Moving up to Level 2 (Pass Level), the number of questions increases to approximately 8-10, and the questions require students to connect the concepts to each other. Once students have successfully answered the questions in Level 2, they can progress to Level 3 (Credit Level), which involves fewer questions (5-8) but requires students to link all the concepts they have learned. As students progress to Level 4 (Distinction), the number of questions further reduces to 4-5, and students must connect the concepts in multiple ways. Finally, at Level 5 (High Distinction), the number of questions decreases to 3-4, and students are required to extend their understanding of Levels 1 to 4 to solve unseen problems. As an example, the TLF-based set of tutorial questions on digital resonators and digital oscillators is provided in [21].

To ensure a systematic approach to learning, students are advised to complete all the questions in TLF Level 2 (Pass) as a baseline before attempting any other questions in the tutorial. Students should then attempt other questions in sequential order (starting with Level 3, Level 4, etc.). The methodical approach of completing tutorial questions in sequential order as per the TLF aids in the progressive development and enhancement of student's analytical and critical thinking skills.

C. *How to Design TLF-Based Final Examination?*

A layout for designing the TLF-based final closed-book exam for the DSP course is illustrated in Fig. 2, where all questions, with multiple parts, were presented in the TLF format. A sample paper is accessible to view [22]. Each student was required to answer only four questions, and if they attempted more than four, only the best four were selected. The total mark a student can get depends on the student's choice of questions.

During the 2- hour written exam, students have the freedom to choose which questions to attempt based on their target level, as outlined in Fig. 2. To achieve TLF Level 2 (Pass), students must answer all four questions (Q1, Q2, Q3, and Q4) under

Level 2. The maximum attainable score is 64. To achieve TLF Level 3 (Credit), students must respond to any three Level 2 questions and one Level 3 question (Q5). The maximum achievable score is 74. For TLF Level 4 (Distinction), students must answer any two Level 2 questions, one Level 3 question, and one Level 4 question (Q6), and the maximum achievable score is 84. Finally, for TLF Level 5, students must answer any one of the Level 2 questions, one Level 3 question, one Level 4 question, and one Level 5 question (Q7). The maximum attainable score is 100.

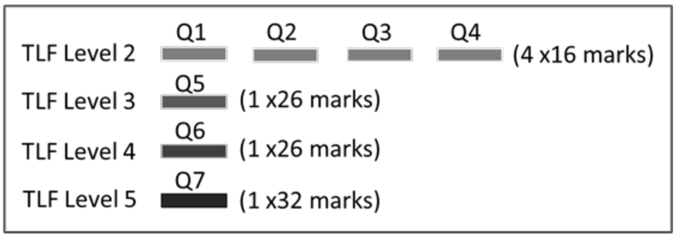

Fig. 2. Designing final written examination in TLF format

D. How to Design TLF Based Mini-Project?

The purpose of the mini project was to offer practical experience of applying the course concepts to create a DSP system. Our approach to designing the mini project involved creating a Level 2 project that incorporated the primary DSP course concepts. We then used Level 2 knowledge as the basis for developing the Level 3 project. Students were required to complete Level 2 before attempting Level 3, as the latter depended on the former. We applied this same approach to all the other project levels. The mini project was designed to gradually increase in complexity from Level 2 to Level 5 based on the TLF. Students had five weeks to complete the project and could choose any TLF level for implementation within that time frame. Some students opted to tackle Level 2 only, while others attempted all levels during the five-week period. The mini project was an individual assignment. The project integrates many concepts learnt during the course. An example of a TLF-based mini-project [23] is given below:

- Level 2: Developing a parallel FIR filter-bank model of the cochlea for analysis and synthesis purposes.
- Level 3: Implementation of a parallel IIR filter-bank model of the cochlea for spectral analysis.
- Level 4: Implementation of a parallel IIR filter-bank model of the cochlea for pitch detection
- Level 5: Integrating an adaptive mechanism into the parallel IIR filter-bank cochlea model that makes the filter-bank adaptive.

E. Overall Course Assessment Plan

The DSP course assessment plan is designed to monitor students' learning progress throughout the term or semester. Continuous assessment is carried out through a range of evaluations, as outlined in Table I. To pass the course, students must achieve a minimum of 50% in both the mini project and the final exam. The final exam evaluates students' analytical, design and critical thinking skills, while the mini project offers practical experience in coding, system design, implementation, conceptual integration, oral presentation, and question-and-answer interaction.

TABLE I

TLF BASED ASSESSMENTS IN 2024

1	Three 20-minute multiple choice quizzes (Weeks 3, 5 & 8) – closed book [TLF Level 1]	15%
2	Lab work Progress - Oral Assessment (Weeks 3 and 5) [TLF Level 2]	10%
3	Mini project (individual) - 20 min Oral Assessment [TLF Levels 2, 3, 4 & 5]	35%
4	Final Exam (2 hours , Closed Book) [TLF Levels 2, 3, 4 & 5]	40%

IV. ARTIFICIAL INTELLIGENCE IN DSP EDUCATION

Artificial Intelligence (AI) tools such as ChatGPT are increasingly being integrated into education [2], [24]. For example, students can input content from any course chapter (see Appendix A) to generate multiple-choice questions of varying difficulty or obtain concise explanations of key concepts. This approach has been demonstrated during class sessions and helps students self-assess and reinforce their understanding of DSP topics. AI tools represent a shift from traditional methods by offering a more personalised and interactive learning experience. Students are encouraged to use these tools as supplementary support, while exercising caution, as AI-generated output may contain inaccuracies.

In both laboratory work and the mini project, students are permitted to use AI tools, including ChatGPT, to aid their learning. However, they are fully responsible for all submitted work, such as designs, reports, and graphs, and must declare any AI use as part of the assessment process.

For laboratory tasks, some weaker students relied on AI tools to generate MATLAB code, while most students wrote their own code and used AI tools to check for errors or validate their solutions. To uphold academic integrity, tutors conducted 5–10 minute oral assessments with each student. These focused on evaluating their understanding of the questions and their ability to explain and modify the code in real time. Without this oral component, it was difficult to confirm whether the submitted results were genuinely the student’s own or primarily AI-generated.

The same process was used for the mini project. It became clear that AI tools could generate reasonably accurate code when provided with the project PDF (Levels 2–5), raising similar concerns about authorship. Oral assessments (approximately 20 minutes per student) were again employed to test students' understanding, their ability to explain their work, and make on-the-spot code modifications.

Based on this experience, we conclude that any assessment involving code generation or writing should include an oral component. We are now moving toward a model that allows students to use AI-generated code, provided they can clearly explain its function and accurately modify it when prompted. This approach aligns with the evolving nature of assessment in an AI-driven learning environment.

V. FEEDBACK AND STUDENT RESPONSE

The Digital Signal Processing course was redesigned based on the TLF framework and was offered in 2021, 2022 and 2024. The enrolment for each year was 185 students, 171 students and 256 students.

A. *Student Feedback*

Due to space constraints, only student feedback from 2024 is presented; however, the feedback from 2021 and 2022 followed similar trends. Student surveys were conducted twice: once after the ten-week delivery of the course and again following the final exam, allowing students to reflect on the entire learning experience. The purpose of this anonymous survey was to gather feedback on the Digital Signal Processing (DSP) course, which was designed using the Tiered Learning Framework. Students were asked to respond to five questions (see Table II) to evaluate the impact of the framework on their learning. Responses were recorded using a five-point Likert scale: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree. The response rate for the survey before the exam was 51% and after the exam 22%. Student responses to the five questions in Table II are illustrated in Figure 3. For simplicity, only the percentages of 'Strongly Agree' and 'Agree' responses are combined and shown before and after the exam. Despite the low response rate following the exam, the feedback clearly indicates an improvement in students' perception of their DSP knowledge acquisition. Student responses reflect a positive learning experience with TLF, highlighting its impact on self-assessment and engagement.

TABLE II

STUDENT SURVEY QUESTIONS

Q1	Tutorial questions based on TLT framework helped me understand what is required to progress to the next level of learning.
Q2	TLT framework helped me to focus on and attain my own preferred target level of learning for the course.
Q3	The use of the TLT framework for the mini-project was helpful in structuring my project-based learning.
Q4	The TLT framework based mini-project was challenging and encouraged me to learn.
Q5	As a result of working on this project my understanding of DSP concepts improved / Reflecting on this term, I feel I have gained sufficient knowledge about DSP.

Some of the students' comments are included for completeness: *"I liked being able to choose what level I wanted", "The TLF made the requirements and expectations of the subject much clearer while also allowing me to determine my own progress and understanding of the subject. "The TLF allowed me to get the fundamental questions right before attempting the harder ones, which is very critical in the learning process", "I think overall I liked the TLF because it put into perspective where I was relative to the level I'd like to achieve. I particularly liked its structure with the tutorial questions because, unlike other subjects, it helped me see what each level of understanding was, rather than having questions mixed together. It also helped me to understand what set of marks I could access in terms of the assignment.".*

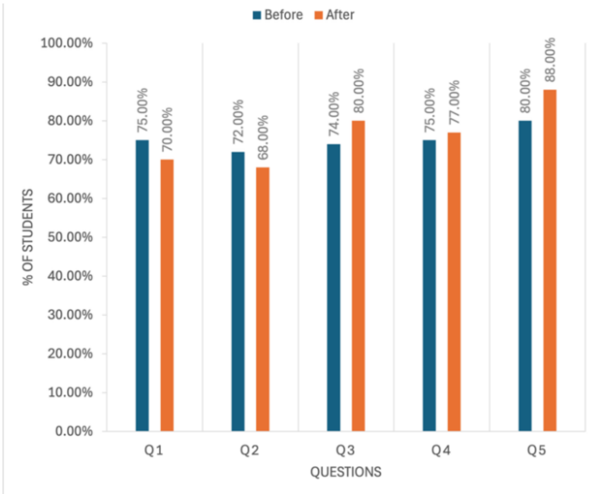

Fig. 3. TLF-Based Learning Experience: Student Responses

B. *Analysis*

To better understand how students progressed through the learning levels, we analysed the shift in TLF levels selected between the mini-project and the final written exam. Of the cohort, 104 students (42.6%) chose the same TLF level for both assessments; 23% at Level 5, 9% at Level 4, 8% at Level 3, and 3% at Level 2. Notably, 11% of students who completed a Level 4 project opted for a Level 3 exam, while 9% of students who did a Level 4 project progressed to a Level 5 exam and so on. This variation reflects students' ability to critically assess their preparedness and select the exam level that best aligned with their capabilities. Similar patterns were observed when the course was offered in 2021 and 2022.

VI. CONCLUSIONS

This paper presented a Tiered Learning Framework for DSP assessments. One of the key advantages of TLF is that each level is aligned with specific grade outcomes, the higher the level, the higher the potential grade, creating a strong motivational incentive for students to progress. The framework encourages students to self-assess their current stage of learning and identify what is required to advance to the next level. It also provides students with greater control and choice over the depth of their learning. Student feedback indicates that TLF enhances their ability to gauge their understanding of the course at their own pace. Moreover, feedback comments from the students suggest they feel more connected to the subject matter when they can evaluate their learning depth and choose their level of engagement.

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Appendix A

The syllabus for the undergraduate Digital Signal Processing course at UNSW Sydney is as follows:

DSP fundamentals (Chapter 1): Discrete-time signals, difference equations, time and frequency domain analysis, Sampling theorem & aliasing, A/D conversion & quantisation errors and noise.

Discrete-time systems (Chapter 2): z-Transform, Pole-zero descriptions, Stability, discrete-time systems, classifications of discrete-time systems, convolution, impulse and frequency response, Discrete-Time Fourier Transform (DTFT), Discrete Fourier Transform, cascade & parallel structures.

Digital filter fundamentals (Chapter 3): FIR & IIR filters, magnitude & phase responses, phase & group delays, min/max phase filters and all-pass filters, linear phase systems, bandwidth & cut-off frequencies of digital filters.

Digital oscillator fundamentals (Chapter 4): Second order IIR resonant filter, stability of a second order filter, digital oscillator.

Digital filter designs (Chapter 5): Notch filter design, analogue filters, FIR linear phase filter design using the windowing method, IIR filter design using Impulse invariant & bilinear transformations, IIR filter design using pole-zero placements.

Multi-rate systems (Chapter 6): Decimation & interpolation, implementation of multi-rate system, modulation, and associated spectra.