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Research Paper

Accelerated Progress in Higher Education STEM Learning via Enhanced Practical Sessions

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Abstract

Higher education (HE) provides insight into learners' future career paths and therefore plays a key role in shaping society. High-quality, professional teaching and learning strategies shape students' future orientations and interests. Students are entitled to the best possible delivery of HE modules and support from providers. This should include not only motivated and motivating tutors and practitioners but also engaging strategies and the integration of theory and practice. In practical STEM (Science, Engineering, Technology, and Mathematics) subjects, the practicals should be planned to bring students closer to their careers through everyday situations and easily digestible scenarios. This could be enhanced by involving students in academic or even educational research. An original concept to extend this approach is the Authentic-Digital Nexus (ADN) Framework. This framework is designed to bridge the gap between theoretical knowledge and real-world application in HE by strategically integrating authentic, problem-based learning with flexible, technology-enhanced delivery methods. The available modern technology allows practitioners to deliver even practical-based sessions remotely, and, as experience suggests, this fades the fear of the difference between face-to-face and remote delivery that has arisen in many cases since the Covid-19 pandemic lockdown. The proposed intervention involves a curriculum redesign within specific STEM modules, structured around the ADN framework.

Keywords: *STEM Education, Student Research, Remote Delivery, Confidence, Motivation*

INTRODUCTION

An important role of a Higher Education (HE) practitioner is to contextualize the significance of the various factors relevant to operating a successful HE setting and to connect them. Every student is entitled to the highest possible quality of education, and it should be grounded in effective innovation and excellence. This is the responsibility of every HE teaching professional. The UK Quality Code for Higher Education (QAA, 2024) outlines the nation's expectations and guides efforts to maintain the reputation of the higher education system.

There has been general concern about the shortage of STEM (Science, Technology, Engineering, and Mathematics) graduates, not only in the UK but also a pervasive worldwide trend. This shortage is particularly acute in many developed nations as they transition further into knowledge-based economies (EngineerinUK, 2025).

A seminal report by Roberts (2002) concluded that several interconnected issues are the major contributing factors. Chief among these are the persistent lack of interest among female students in pursuing STEM subjects and widespread reports of negative experiences within the existing STEM education framework—a situation partly attributable to the critical shortage of motivated and motivating science teachers in the education system (SThree, 2025).

Mutual respect is a key requirement for successful education (Cohen et al., 2011), regardless of the stage, from primary school to postgraduate studies. By naturally applying mutual respect and clear explanations, the educational practitioner should be able to build a friendly and productive teaching and learning environment where students feel safe exploring concepts and

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thus make good progress. However, a lack of mutual respect can pose challenges, leading to quality issues and a lack of progress (Ingram et al., 2025).

Clarity, clear expectations, and differentiated support effectively use session time and crucially reduce unnecessary disruptions and off-topic questions from students, as they feel their needs are being anticipated and met (NasirpourOsgoei & Obembe, 2025). Even more, when students feel genuinely valued, and their work and effort are acknowledged in different ways—whether through specific praise or tangible opportunities—that recognition puts them on an accelerated learning path toward mastery. A great way to foster deeper engagement and a sense of value is to invite them to participate in active research and inquiry-based projects.

There is a lack of empirical research that specifically links adherence to national quality assurance frameworks (such as the UK Quality Code) to tangible improvements in STEM student recruitment, retention rates, or the closing of the gender gap identified by Roberts (2002). Furthermore, the literature does not provide comprehensive evidence on how to effectively integrate "active research and inquiry-based projects" with modern technology, especially in scalable or remote formats.

In this study, a diverse cohort of 300 UK-based engineering and biomedical students from a wide range of socio-economic, ethnic, and educational backgrounds has been provided with effective teaching and learning strategies, complemented by appropriate academic and pastoral support designed to foster success. Clear behavioral boundaries are set collectively, and the code of conduct and academic requirements are explicitly clarified at the start of the academic year to ensure all participants begin with a shared understanding of expectations.

The specific group of students analyzed included targeted, smaller cohorts of both biomedical and engineering students, in which this supportive teaching and learning environment was more feasible to implement and study intensively than it typically would be in large, anonymous undergraduate lecture groups. The myriad advantages of this focused approach, together with the measurable effectiveness and key factors in integrating contemporary digital technology and advanced remote delivery as essential parts of students' learning journeys and individual research efforts, will be thoroughly discussed and analyzed in this comprehensive paper.

In this paper, a brief but critical review of practical pedagogical approaches and delivery methods currently employed in higher education will be presented. This analysis is paired intrinsically with an examination of the documented effectiveness of incorporating authentic student research opportunities in achieving accelerated learning outcomes. Furthermore, the necessary and relevant adaptation strategies for effective remote delivery platforms will be extensively covered, as they are key factors in student retention and success, particularly within higher-education STEM disciplines, and address modern challenges and technological advancements in the educational landscape.

Specific research objectives include evaluating the impact of inquiry-based projects on STEM student self-efficacy and career persistence through quantitative engagement metrics. Furthermore, this study aims to assess the efficacy of diverse digital collaboration tools in fostering a sense of professional belonging and mastery among learners participating in remote research-led modules.

LITERATURE REVIEW

In the realm of modern higher education, it is fundamentally important to provide students with a solid academic foundation via the considered combination of formal lectures and interactive tutorials. This integrated approach ensures that theoretical knowledge is delivered and understood in a structured environment.

Once this solid foundational knowledge is acquired, the learning process must evolve, and that knowledge must be applied vigorously in practical, real-world scenarios. In general, any effective practical session requires thorough preparation from students—this crucial requirement applies not only to traditional STEM subjects but also to practical-based learning across all disciplines.

Tutors and faculty often observe recurring confidence issues among students, particularly when they transition into hands-on practical sessions. Interestingly, the social media craze, with its emphasis on rapid iteration and sharing, inadvertently helps reduce students' initial anxiety and worry by normalizing attempts and progress. The "fail faster" approach, when strategically adopted and championed by tutors, helps make communication between instructor and learner more effective and, overall, accelerates personal development.

Specifically, if, either during formal demonstrations or in student-led practical exercises, students are firstly asked to articulate how they would personally approach solving a particular problem, and then the problem is collaboratively fixed together, this would easily build their immediate confidence and, as a direct consequence, significantly help with their accelerated academic progress.

Furthermore, leveraging external expertise by including relevant guest speakers can significantly foster students' confidence and broaden their horizons. These speakers might include successful former students who can relate directly to current challenges, successful active researchers or academics within STEM fields, accomplished artists in media and art, or even dynamic company directors offering industry insights.

If these insightful sessions are well-planned, structured, and targeted, students will be uplifted by essential positivity and inspiring examples of relatable success stories. However, this is just an initial step in a longer motivational journey, and motivation should be further fostered and sustained through long-term activities, such as immersive student projects or meaningful research opportunities, thereby solidifying their engagement and future potential.

A recent study (Bohm et al., 2025) indicates that social media-based collaborative learning improves student self-efficacy, motivation, and performance by approximately 15%. These platforms normalize iterative attempts and peer knowledge sharing, transforming "failure" into a collaborative, rapid feedback loop that aligns with students' digital habits.

Recent meta-analyses (Sahoo & Khuntia, 2024) found that adaptive scaffolding—where instructors offer guidance based on students' stated approaches—has the largest effect size on developing problem-solving skills. Articulating a solution before collaborative fixing effectively bridges the Zone of Proximal Development (ZPD) and manages cognitive load by reducing external distractions.

The widespread adoption of active learning methodologies is one of the most significant drivers of progress in contemporary STEM education reform. Active learning strategies have consistently demonstrated remarkable effectiveness in improving educational outcomes. Notably, they have shown a substantial 55% reduction in student failure rates compared to traditional lecturing approaches that rely purely on passive reception of information.

These modern pedagogies involve a diverse range of approaches, from collaborative problem-solving exercises to student-centered instruction, all of which strategically position learners as active participants in their own knowledge construction rather than merely passive recipients of information (Freeman et al., 2014).

Successful STEM modules nowadays should move beyond fixed instructions to adaptive scaffolding. Effective instructors should require students to articulate a "personal approach" first, allowing the tutor to tailor support to the student's specific cognitive gaps. Curricula should integrate the "rapid iteration" mindset of social media into formal practicals, using collaborative tools to foster a community of inquiry in which "failing fast" is socially normalized rather than academically penalized. The inclusion of guest speakers is benchmarked not just by frequency but by relatability; successful outcomes depend on students perceiving these role models as "attainable" figures who share similar backgrounds or challenges.

Numerous studies consistently demonstrate that students enrolled in active learning environments show statistically higher levels of engagement, increased retention of factual knowledge, greater confidence in their content knowledge, an enhanced ability to apply and synthesize complex information, an increased sense of belonging within the academic community, and a stronger overall sense of community (Duke Bass Connections, 2020; Freeman et al., 2014). Importantly, these tangible benefits extend across all STEM disciplines and various class sizes. However, the greatest positive effects are most evident in smaller, more intimate classes—a finding clearly demonstrated in our study.

Practical activities, whether delivered in an immersive physical lab setting or an innovative online simulation environment, are widely considered the best available tools for promoting significant progress in STEM subjects (Millar, 2004) and other practice-related fields such as design or fine arts (Katajavuori, 2006). They efficiently provide the required combination of foundational information delivery and essential visual demonstrations.

The structure of these practical sessions should always include comprehensive coverage of crucial safety aspects and clearly demonstrate activities performed by an experienced person. However, it should also quickly move students to the next critical stage, where they independently carry out the individual steps, either in small collaborative groups or individually. This transition to hands-on student practicals helps students learn and internalize complex information spontaneously and intuitively—often without their consciously realizing they are deeply engaged in rigorous learning processes.

Furthermore, these integrated practicals uniquely enable close monitoring of each student's progress and the correction of nascent misconceptions in real time. Their core element is complex problem-solving, an approach that inherently enables creativity and critical thinking to be combined synergistically.

It is hypothesized that students required to articulate their problem-solving rationale before receiving collaborative instructor feedback will demonstrate higher problem-solving self-efficacy than those receiving traditional "corrective" feedback. The strategic use of social-media-like "rapid iteration" protocols in STEM practicals will significantly reduce pre-session anxiety among transitional students. Exposure to relatable guest speakers (alums), paired with subsequent long-term inquiry-based projects, will lead to higher persistence in STEM careers than role-model exposure alone.

RESEARCH METHOD

This study employs a quantitative research methodology to systematically investigate and measure students' perceptions and confidence. Specifically, it uses a descriptive, cross-sectional survey design. This choice allows for the collection of numerical data from a large, specific population at a single point in time to identify patterns, averages, and correlations between variables (e.g., student confidence levels). The quantitative approach ensures statistical rigor and enables generalization of findings to the broader population of STEM students.

A convenience sampling strategy was used, targeting all available fully anonymized first-year Biomedical and Engineering students enrolled in specific modules at a particular university. While this approach is practical and cost-effective for reaching 300 respondents, it is a non-probability sampling method. To mitigate potential bias, efforts were made to ensure a balanced mix of students from both disciplines.

Data was collected using a self-administered online survey via a secure institutional platform

(SurveyMonkey). All responses were fully anonymized to encourage honest answers about sensitive topics such as confidence issues and fear of failure. The respondent students were randomly selected from a wide range of ethnic and socio-economic backgrounds, including white, Asian, African, and Latino groups. They were aged 18 to 21 years, with an average age of 19.2. The core instrument consisted of seven items, each rated on a Likert scale, allowing students to express the strength of their agreement or disagreement.

The survey items were developed based on the themes identified during the initial literature review. Anonymized experts in educational psychology and STEM pedagogy reviewed the questions to ensure relevance and coverage. An appropriate data analysis strategy for this study involved a tiered approach that addressed the 7-item Likert instrument, the cross-sectional design, and the comparison between Biomedical and Engineering student groups.

FINDINGS AND DISCUSSION

In our study, we observed that students typically arrive at the start of practical sessions with only moderate confidence; consequently, a portion of valuable session time is traditionally spent covering vital safety details and potential hazards. It was evident from our data analysis that administering a set of relevant, compulsory online quiz questions prior to attendance significantly helped students prepare more thoroughly for the practical sessions and substantially increased their baseline confidence—a finding confirmed by 90% of students who responded to our survey.

If passing such a preparatory quiz is formally set as an essential requirement even to carry out the physical practical, students subsequently start to show a measurably higher level of understanding and readiness for the practical sessions, allowing the educator to focus more efficiently on remaining nuanced misconceptions rather than redundantly covering the basic ideas and core concepts they should already understand.

Students frequently make excuses for their lack of understanding or missed lessons, especially if the primary delivery method is not engaging or motivating enough to sustain their consistent attention. It is widely considered a good pedagogical practice to proactively make the sessions' core content and supplementary practice materials readily available to students (for example, in the form of preparatory quiz questions or reading materials) via a robust virtual learning environment (VLE; contemporary platforms include Moodle (2025), or Google Classroom) at least one full session before the actual lesson takes place.

By doing this, students can effectively prepare in advance, and their foundational preparation significantly helps the educator use the valuable in-session time more effectively to accelerate quality learning and deeper engagement. Also, facilitating their interaction with the material and the instructor via email or other communication platforms (such as Google Meet or Zoom) helps make differentiation more effective by leveling the playing field and equalizing the general knowledge base before the synchronous session begins. The students should ideally be thoroughly introduced to the functionalities of these platforms on their first enrolment or during a dedicated induction period.

By the time of the actual sessions, the students will be empowered to prove a solid general understanding of the background theory and the practical tasks themselves. If students are encouraged to actively use portable devices or tablets during sessions, they will get used to navigating these platforms and techniques very quickly—and they universally find them to be very useful and effective tools. This efficacy is demonstrated by the outstanding 9.5/10 satisfaction rating from our recent internal survey of a representative sample of 100 students.

To ensure a comprehensive analysis of these pedagogical strategies, the survey design deliberately captured both neutral and critical perspectives, as well as positive feedback. While the high satisfaction rating indicates general success, qualitative feedback revealed that a small subset of students initially viewed pre-session requirements as a "burden" on their independent study time, and some expressed concerns regarding the digital accessibility of VLE platforms. By discussing these critical viewpoints, we were able to refine our delivery to better support students who struggle with self-regulation or have limited access to hardware, ensuring that the technology serves as an inclusive bridge rather than a barrier to engagement.

According to our research, based on a sample of 300 first-year Biomedical and Engineering students, the regular use of online simulation tools (PhET Colorado, 2025; BBC Bitesize, 2025) accelerates learning and increases students' encouragement and motivation. This is clearly evidenced by the survey shown in Tables 1 and 2, where students were asked how much time they spent, on average, per practical session before and after adopting online simulation, and how confident they were, on average, in the practical topics.

Table 1. Number of responses to the question, “How much time did you spend on average on preparing for a practical session, before and after adopting the online simulations as part of the learning process?”

	Less than 30 minutes	**30 to 60 minutes**	**1-2 hours**	**More than 2 hours**
Before	21	86	94	99
After	25	114	152	9

Table 2. Number of responses to the question, “How confident were you on average about the knowledge and skills required to carry out practical safety and confidentiality, before and after adopting the online simulations as part of the learning process?”

	Not confident	**Neither unconfident nor confident**	**Somewhat confident**	**Very confident**
Before	146	96	48	10
After	22	79	141	58

During this early phase of practical learning, many students even learn to use these tools. Before students are taught about the importance of accurate note-taking, health and safety, and attention to practical details, it is beneficial to ask them to conduct background research on related issues. This is supported by another survey in which they were asked how useful it was to read a relevant short piece of literature related to the practical.

Table 3. Number of responses to the question, “How much did reading a relevant short literature help with understanding the importance and details of the practical to be carried out?”

Not relevant	**Neither relevant nor irrelevant**	**Relevant**	**Very relevant**
11	41	96	152

In general, effective teaching and learning can occur robustly if formal information delivery and active practice are regularly and strategically combined, and if students are consistently motivated and challenged in a variety of ways throughout their academic journey. This holistic approach moves beyond simple information transfer to foster deep understanding and engagement.

Furthermore, it is crucial for long-term retention to contextualize new, complex concepts, either through relatable everyday situations or, at least, through realistic professional contexts that students can easily visualize and connect with. This pedagogical approach was specifically and successfully tested in the delivery of an abstract chemistry topic, "Chemical equilibrium," which is often a difficult concept for many first-year biomedical students to grasp in theory alone.

In this highly effective practical task designed to bridge theory and application, the students needed to apply chemical principles and analytical techniques to determine the precise vitamin C concentration in various everyday fruits. This practical brought the abstract, theoretical concept of chemical equilibrium much closer and made it far more tangible to them through a direct, relevant everyday situation.

Through their own hands-on work and discovery, the students universally left the session with a clear, solidified understanding of the topic and significant encouragement and motivation to continue their studies. This enhanced understanding and positive engagement were robustly evidenced by a post-session survey where 100 biomedical students were systematically asked to rate the clarity of their understanding and the perceived relevance of the practical task to their course and future careers.

The results indicated high satisfaction and deep learning outcomes, confirming the efficacy of contextualized, practical-based learning. This approach solidified a complex abstract concept using a real-world scenario, a method easily applicable across various scientific and non-scientific disciplines to improve educational outcomes and student confidence. The integration of practical application into theoretical learning fosters both critical thinking skills and a deeper appreciation for how academic knowledge translates into practical utility, preparing students more effectively for their future professions and research endeavors.

Table 4. Number of responses to the question, “How relevant do you feel the practical session was in everyday biomedicine?”

Not relevant	Neither relevant nor irrelevant	Relevant	Very relevant
2	15	51	32

Table 5. Number of responses to the question, “How easy was it to understand the details of the practical?”

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
3	7	15	50	25

To make learning more effective while maintaining the session's pace, the students were advised to read background materials on vitamin C as a biochemical molecule and on the applicable analytical method.

The results illustrate a successful implementation of contextualized experiential learning, demonstrating how bridging the gap between abstract theory and tangible application can overcome significant pedagogical hurdles in STEM education. By utilizing the "Chemical equilibrium" module as a case study, the interpretation reveals that student engagement and cognitive retention are significantly enhanced when learners can map complex academic concepts onto relatable real-world scenarios, such as analyzing vitamin C in everyday fruits. This approach serves as a cognitive anchor, transforming a traditionally difficult and passive learning experience into an active process of discovery and professional identity formation.

The high satisfaction and clarity reported by the 100 biomedical students provide empirical validation of this holistic model, suggesting that when educators prioritize practical utility and personal relevance, they not only transfer information but also effectively catalyze student confidence and long-term academic persistence. This methodology establishes a scalable blueprint for higher education, in which the integration of theory and practice is a critical driver in preparing students for the multifaceted challenges of their future professional careers (Sahoo & Khuntia, 2024).

Another example of this was when mechanical principles of robotics were taught to first-year engineering students; they were given a practical task: building robotic arms in pairs. These students were also advised to read literature materials on robotic arms before conducting the practical. An important element of the task was to study the different types of movement and find ways to further improve the model. A similar survey was conducted as with the biomedical students. Here, 100 students were surveyed as well.

Table 6. Number of responses to the question, "How relevant do you feel the practical session was in everyday engineering?"

Not relevant	Neither relevant nor irrelevant	Relevant	Very relevant
4	8	62	26

Table 7. Number of responses to the question, "How easy was it to understand the details of the practical?"

Very difficult	Difficult	Neither difficult nor easy	Easy	Very easy
3	4	14	52	27

Teaching strategies across all educational levels need to be regularly reviewed, refined, and dynamically adjusted to align with relevant academic levels and the diverse abilities within any cohort. Maintaining small group sizes in higher education modules makes it far more feasible and practical for the practitioner or instructor to quickly become familiar with individual students, understand their specific abilities, identify learning styles, and efficiently recognize potential knowledge gaps. This familiarity enables targeted, bespoke support mechanisms.

Additional group collaboration opportunities and dedicated one-to-one support sessions could be seamlessly provided to students by patiently answering their specific questions about the material or assignments and thoroughly discussing them. This personalized approach is a very direct, highly efficient, and quick way for them to embed complex information and solidify their burgeoning knowledge base. This immediate feedback loop ensures that misunderstandings are addressed rapidly, preventing them from hindering future learning outcomes and fostering a more robust, individualized educational experience.

Our comprehensive research also robustly demonstrates that the strategic combination of tutorials, interactive workshops, and formal lectures, coupled with regular, hands-on practical sessions, consistently enables us to set all students on the correct trajectory toward accelerated learning and academic success.

As a direct and measurable consequence of this blended pedagogical approach, it can significantly promote good academic progress and higher achievement rates. When logistically possible, the regular availability of tutors—whether through scheduled office hours or efficient remote support channels—can dramatically increase overall student confidence and ensure that any lingering misconceptions they hold about key terms or complex theories are corrected well before the high-stakes pressure of coursework deadlines and final exams mounts.

These proactive interventions are critical touchpoints. Consequently, all these interconnected strategies and support systems collectively contribute to better long-term academic progress, improved student retention, and ultimately, superior final achievement levels across the student cohort. The consistency of support and the variety of delivery methods create a resilient framework for student success that addresses diverse learning needs.

These results underscore the critical role of personalized, multimodal pedagogy, in which the efficacy of higher education is measured by its ability to adapt to diverse learner profiles through high-frequency touchpoints. By prioritizing small group sizes, the framework facilitates a transition from generic information delivery to bespoke academic support, allowing practitioners to identify and bridge individual knowledge gaps before they become systemic barriers. This strategy aligns with 2026 educational benchmarks that emphasize the "immediate feedback loop" as a primary driver of student retention.

The synthesis of tutorials, workshops, and practicals serves as a resilient success framework, ensuring that students are not merely passive recipients but active participants on an "accelerated learning trajectory." Ultimately, the text argues that by lowering barriers to tutor accessibility—whether through in-person office hours or remote digital channels—institutions can mitigate the high-stakes pressure of assessments, leading to measurably higher achievement levels and long-term academic persistence.

Appropriate expectations and facilitating assessments in STEM

An ideal STEM and most practical-based sessions should follow the following strategy:

1. Supporting materials are provided to students that guide them before, during, and after the actual sessions.
2. The students carry out their background research both outside and inside sessions.
3. The preparation for and running of a practical requires knowledge and application of safety, too.

Therefore, a clearly written risk assessment and summary of methods must be completed and checked by the tutor before the practical. These two are organic parts of any technical laboratory report. A report that is written with GLP (good laboratory practice) will contain the following sections: risk assessment, methods and materials, hypothesis, results, discussions, conclusions, and bibliography.

Assessment is an integral part of any module delivery framework, and vital practical sessions should certainly not be exempt from this continuous evaluative process. When assessment is integrated seamlessly and regularly into practical work, students quickly get used to the routine. This established routine provides structure and predictability, which can significantly help them plan and manage their time effectively. This structured approach fosters noticeable improvements in their short-, medium-, and long-term academic progress. This constant cycle of assessment and planning builds resilience and organizational skills vital for higher education and professional life.

Students' overall progress should be monitored regularly and systematically, either during intensive theoretical lectures or within hands-on practical sessions. To maximize the effectiveness of this monitoring, they should receive regular verbal (and sometimes written) feedback promptly. It has been empirically shown across numerous educational contexts that instantaneous feedback significantly accelerates learning and understanding, primarily by quickly eliminating misconceptions and misunderstandings before they become deeply ingrained in students' minds.

This efficacy is robustly evidenced by the survey results shown below the text, in which a diverse group of 300 biomedical and engineering students was asked to quantify the impact of receiving regular, instantaneous feedback during their practical sessions on their personal confidence and measurable academic progress. The high positive response rate clearly underscores the critical role of timely feedback in enhancing both confidence and the acquisition of practical skills in demanding STEM disciplines. This rapid corrective feedback mechanism is a cornerstone of effective pedagogical practice in skill-based learning environments.

Furthermore, integrating assessment within practical sessions provides valuable insights for educators. It enables real-time identification of common difficulties students experience, allowing instructors to adapt their teaching methods and provide targeted support. This adaptive approach ensures that the curriculum remains responsive to student needs and promotes a deeper understanding of the subject matter.

When students are aware that their practical work is being assessed, they are often more engaged and motivated to participate and actively strive for excellence. This intrinsic motivation, coupled with the external feedback from assessment, creates a powerful synergy that enhances the overall learning experience. The assessment process itself becomes a learning opportunity, encouraging students to reflect on their performance and identify areas for improvement. This metacognitive skill development is crucial for lifelong learning and professional growth.

Beyond academic benefits, regular assessment in practical sessions also prepares students for the realities of their future careers. Many professions require individuals to perform tasks with precision and accuracy, evaluate their own work, and accept constructive criticism. By incorporating assessment into practical learning, educational institutions are equipping students with essential skills: self-evaluation, critical thinking, and effective response to feedback – competencies that are highly valued in the workplace.

This practical application of assessment helps bridge the gap between theoretical knowledge and practical skills, ensuring that graduates are well-prepared to meet the demands of their chosen fields. The routine of being assessed in a practical setting also helps students develop a professional demeanor and the ability to perform under pressure, which are invaluable assets in any professional environment. The systematic nature of regular assessment instills a sense of accountability and encourages students to take ownership of their learning journey.

Table 8. Number of responses to the question, "How much did instantaneous feedback help with your confidence in the practical and progressing with it?"

Not at all	Neutral	A bit	A lot
7	55	98	140

Once solid foundations are effectively laid in both theory and practice, and crucial student confidence is consistently built and reinforced through guided practice, those initial practical elements can organically evolve into more independent, self-directed student research initiatives. Research in higher education should be treated as an essential, integrated element of academic practice, not merely a selective privilege reserved for a few elite students.

Engaging in student research can significantly benefit not only students' development but also the practitioners involved, allowing them to further refine their teaching practices based on observed student engagement and outcomes. The participating students' capacity for critical thinking and problem-solving can be genuinely challenged in authentic, real-world research scenarios. According to the findings of this study, this high level of internal and external motivation substantially helps them advance their academic skills and increase their active engagement in the overall learning process.

From time to time, practitioners inevitably experience challenges in their module delivery, particularly when delivering more complex or abstract subjects. Ideally, these inherent challenges increase a professional educator's inspiration and intrinsic motivation, helping them view the existing module materials from a fresh student's perspective and fostering empathy and clarity.

While freshly started and foundation year students are typically expected to answer direct and open questions to demonstrate basic comprehension simply, more independent learning is actively facilitated at Levels 4 and 5 (typically undergraduate years two and three), where students can be asked to prepare comprehensive in-session presentations that they later present confidently in front of the entire class, followed by constructive peer-feedback sessions.

Graduating students at Level 6 or above may be formally required to critically analyze complex academic publications and synthesize information to draw their own sophisticated conclusions, thereby increasing their confidence in advanced critical analysis and nuanced evaluation. This tiered strategy can be easily applied in both traditional face-to-face and remote synchronous sessions, demonstrating its versatility. In any delivery method, the expected learning outcomes should always be Specific, Measurable, Achievable, Realistic, and Time-bound (SMART)—these clear objectives are key to success and effective learning (Chatterjee & Corral, 2017).

Visual activities, including carefully planned demonstrations, interactive simulations, and structured role-play, are powerful pedagogical tools designed to help students grasp basic concepts and understand the critical links among them (Bobek & Tversky, 2016). Consequently, many sessions across disciplines should dynamically incorporate visualization whenever it is both practical and relevant. These highly engaging activities help not only to embed factual information and theoretical knowledge more deeply in students' minds but also serve as effective mechanisms to facilitate and consistently check progress and understanding during the session.

A specific test was conducted for a cohort of 100 first-year biomedical students: an important, assessed part of their practical task was to physically build complex molecular models for different essential organic compounds (specifically amino acids, carbohydrates, fatty acids, and nucleic acid bases). Students were actively allowed to work in pairs, and half a session was allocated for them to practice constructing these models and investigate different chemical structures hands-on. The same idea was successfully applied in a parallel first-year engineering class as well. In this engineering scenario, students were asked to design environmentally friendly lampposts in scaled-down dimensions using CAD software, and then bring their designs to life by printing them on a 3D printer.

These practical, hands-on activities made the observed sessions vibrant and engaging, providing meaningful and genuinely enjoyable learning experiences for all participants. Misconceptions were immediately identified, and the practitioner continually monitored progress through informal conversation and challenging, probing questions.

In the next foundational step, the students were required to demonstrate their completed models to one another and were actively encouraged to make constructive, critical comments and peer evaluations. Finally, to solidify the integration of digital skills, they took photos and videos of their finished models, which they subsequently included as evidence in their formal assessment report.

It is critically important in the current educational landscape to examine the profound effect of online delivery and necessary alternatives to traditional physical practical sessions. During the unforeseen circumstances of the Covid lockdown, online sessions (via platforms like Google Meet and Zoom) became the only available way of teaching and interacting.

Consequently, typical face-to-face practical sessions and assignments in Higher Education were rapidly replaced with remote alternatives such as detailed literature reviews, theoretical experiments, virtual simulations, and data analysis tasks. Crucially, the live and recorded remote sessions provided opportunities for critical questioning, effective assessments, and essential student support comparable to those in in-person classes, ensuring a continuous path to academic progress despite the physical constraints.

We have systematically interviewed 20 experienced lecturers and tutors who work in diverse areas of Higher Education across various institutions. Every single one of the interviewees unequivocally told me that they actively encouraged students to become more independent in their learning journey by strategically leveraging the extensive opportunities provided by both group communication platforms and direct one-to-one communication with practitioners. These ongoing opportunities for interaction further enabled students to effectively practice and develop essential teamwork and research skills crucial to their future careers.

On the other hand, the practitioners universally highlighted a notable shift, observing that the role of student representatives, who serve as crucial intermediaries to forward questions, concerns, and feedback from the student body to educators and managers, has become significantly more important and central to the educational dialogue since the onset of the global pandemic. Overall, their collective professional opinion was that the mandated shift to remote delivery did not negatively change the overall effectiveness and quality of teaching and learning outcomes, nor did it hinder the academic progress of the students involved.

They also reported robust data indicating that students’ engagement levels did not significantly drop compared with traditional physical sessions—as demonstrated by an average attendance rate of 74% among the 500 students in online sessions, which is remarkably close to the 79% typically observed in face-to-face sessions.

The findings from this research challenge and expand established theories of learning and confidence development, offering a novel and distinct contribution to educational pedagogy. The study specifically re-evaluates Bandura's self-efficacy model (Bandura, 1977), which has historically centered on direct, hands-on "mastery experiences" as the primary mechanism for building student confidence. This research introduces a critical refinement: it demonstrates that sophisticated, technology-mediated vicarious experiences within virtual laboratory environments can serve as comparably potent and significantly more scalable alternatives to traditional physical mastery, particularly when integrated with personalized, responsive instructor feedback.

The clear advantages of remote delivery and online learning noted by staff and students include significant time savings from traveling to and from university premises and a significantly reduced risk of contracting illnesses during a public health crisis. On the other hand, acknowledged disadvantages include the obvious lack of physical access to specialized practical equipment and the lack of peers and tutors available for spontaneous interaction.

However, according to the robust data collected, the latter drawback did not count much in the grand scheme, which is evidenced by the similarly good progress shown during the pandemic lockdown periods and the compelling survey result of 500 students which showed that an outstanding 92% of the students were equally happy and satisfied with the remote delivery methods, including the observed virtual practicals and the effective replacing simulations.

The results extend Lave and Wenger's theory (Lave & Wenger, 1991) of legitimate peripheral participation. The key new insight is that supportive, flexible, and remote Virtual Learning Environment (VLE) delivery methods dramatically reduce the initial barriers to entry for students seeking to join highly technical "communities of practice." This work provides a fundamental shift in understanding, arguing that geographical or digital 'remoteness' is not synonymous with 'distance' from quality learning or community engagement. This re-conceptualization positions the pedagogical presence of the educator—rather than mere physical proximity—as the core driver of academic confidence and success in the contemporary higher education environment.

CONCLUSIONS

A highly motivated higher education practitioner does not focus solely on preparing and using appropriate teaching and learning strategies within the rigid confines of the curriculum; they also earnestly strive to understand their students' unique backgrounds. This deep understanding enables them to dynamically adopt and develop bespoke strategies that accelerate learning and sustainably enhance students' academic confidence. In practical-based subjects such as STEM (Science, Technology, Engineering, and Mathematics), it is fundamentally important to seamlessly combine a robust theoretical foundation with engaging, motivating practical applications.

Crucially, modern technology allows skilled practitioners to deliver these intricate sessions remotely without compromising quality. This capability is not limited to standard revision periods or theoretical sessions; it increasingly enables traditional, hands-on practical sessions to be effectively replaced or supplemented with highly sophisticated virtual lab environments and advanced simulation-based delivery methods, ensuring continuity and accessibility.

To effectively support students, an ideal practitioner aims for a comprehensive understanding of their individual circumstances and challenges. It is widely recognized that students frequently encounter significant stress, particularly as assignment deadlines and exams approach. Cultivating a supportive and engaging environment, coupled with stimulating learning sessions, has been shown to help students quickly rebuild their confidence. This renewed confidence can then propel them towards accelerated and enhanced learning. A supportive atmosphere can encompass various elements designed to promote well-being and academic success.

This study's findings offer a novel theoretical contribution by challenging and extending existing frameworks of situated learning and self-efficacy theory. Traditionally, Bandura's self-efficacy model emphasizes mastery experiences as central to confidence building. Our results, however, demonstrate that technologically-mediated vicarious experiences within sophisticated virtual lab environments can serve as equally powerful and scalable alternatives to traditional "hands-on" mastery, especially when combined with a practitioner's bespoke, rapid-feedback scaffolding.

Furthermore, these findings extend Lave and Wenger's concept of legitimate peripheral participation; the novel insight here is that supportive, remote, and flexible VLE delivery methods effectively lower the barrier to entry for students to engage in highly technical "communities of practice" from the very beginning of their studies. This work highlights a new understanding that perceived 'remoteness' does not equate to 'distance' from learning quality or community engagement, fundamentally shifting the emphasis from physical presence to pedagogical presence as the key driver of academic confidence and success in the post-pandemic HE landscape.

LIMITATION & FURTHER RESEARCH

The argument for an ideal educator hinges on the presence of a "highly motivated" and "ideal" practitioner willing to adopt bespoke strategies and to understand students' backgrounds deeply. This highly individualized approach is difficult to scale across a large university department with diverse staffing levels, potentially limiting the real-world applicability of the findings. Virtual labs can effectively "replace or supplement" traditional hands-on practicals without compromising quality. This claim may not generalize to all STEM disciplines, particularly those requiring fine motor skills, physical manipulation of real equipment, or tactile feedback that simulations cannot yet fully replicate.

The success of the described methods relies heavily on access to "highly sophisticated" virtual environments and robust VLE platforms. This introduces a potential bias against students who face a "digital divide," lacking reliable internet access, modern devices, or the digital literacy to navigate these platforms effectively, which could impact the equity of the educational experience.

Based on the novel insights and identified limitations, the following specific recommendations for future research can be proposed:

1. Longitudinal Comparative Studies: Conduct long-term longitudinal studies (tracking students from year one to graduation) to compare the sustained impact of virtual lab experiences versus traditional hands-on practicals on the development of highly specific psychomotor and tactile skills required for practical application in professional settings. This would empirically test the "without compromising quality" claim.
2. Scalability and Implementation Feasibility: Future research could move beyond the "ideal practitioner" model to investigate the feasibility and effectiveness of implementing these bespoke, rapid-feedback virtual strategies at an institutional scale. This research should specifically focus on the training requirements for faculty and the cost-benefit analysis of deploying sophisticated virtual lab environments across entire departments.

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