



*People's Democratic Republic of Algeria
Ministry of Higher Education and
Scientific Research*



**SETIF –1 UNIVERSITY FERHAT ABBAS
FACULTY OF NATURE AND LIFE SCIENCES
DEPARTEMENT OF BIOCHIMISTRY**

MASTER'S THESIS FOR OBTAINING THE DIPLOMA

Diploma: Start Up – Label Patent

Special filed: Applied Biochemistry

TOPIC:

**Advancing Biochemistry Practical Training Through Digital
Transformation: A Blended Laboratory Framework for
Algerian Universities**

Presented by:

BOUAFASSA Khaoula
BELATTACHE Ilham

Presented publically in: **11/12/2025**

Jury :

Chair :

Supervisors :

Examiner :

Incubator

Representative :

Economic Partner : Khabcheche Houda

KHENNOUF Seddik
KARBAB Ahlem
HARRAG Nassir
CHAREF Nouredine
KADA Seoussen
MAAMACHE Walid

Pr. UFA Setif-1
MCA. UFA Setif-1
MCA. UFA Setif-1
Pr. UFA Setif-1
MCB. UFA Setif-1
MCA. UFA Setif-1

Director of Life skills
institute, Setif

*Laboratory of applied biochemistry
2024-2025*

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

وَأَخِرُ وَغَوَا فُحْمٌ أَنَّ الْحَمْدُ لِلَّهِ «

« رَبُّ الْعَالَمِينَ

صدق الله العظيم

Acknowledgements

All praise and thanks are due to Allah, the Almighty, for the strength, health, and patience He has bestowed upon us throughout these years of study. Upon completing this modest endeavor, we would like to express our profound gratitude and sincere appreciation to the following:

First and foremost, we extend our deepest and most heartfelt thanks to our dissertation supervisor, **Dr. Ahlem KARBAB** at Setif-1 University Ferhat Abbas, for her invaluable guidance, enduring patience, and continuous encouragement throughout the preparation of this work.

We also extend our sincere gratitude to our dissertation supervisor, **Dr. HARRAG Nassir** for his academic guidance, unwavering support, and significant contribution to the practical aspects and development of the platform utilized in this project.

Furthermore, we are profoundly grateful to **Pr. CHAREF Noureddine**, our co-supervisor, for his precious counsel, continuous support, and insightful mentorship during the various stages of this research.

We are honored and deeply thankful to the esteemed members of the dissertation examination committee for their time and expertise. Our sincere thanks go to:

Pr. SEDDIK Khennouf, President, for accepting to preside over this work. We also extend our appreciation to **Dr. KADA Seoussen**, for kindly accepting to serve as the examiner and for her insightful remarks and constructive feedback.

We also wish to thank our **incubator Representative, Dr. MAAMACHE Walid**, whose assistance and collaboration were greatly appreciated.

We would like to express my warm gratitude to **our Economic Partner, Ms. Khabcheche Houda**, Director of the Life Skills Institute, Setif, for her support, cooperation, and contribution to the practical aspects of this work.

We are truly grateful for their meticulous evaluation of our work and the valuable feedback they provided, which greatly enriched the final outcome.

Finally, we extend our appreciation to all the teaching staff of the Faculty of Nature and Life Sciences, to everyone who supervised the theoretical components of our studies, and to all our family, friends, and colleagues both near and far for their unwavering support and encouragement.

Dedication

After five years of fatigue and hardship in the pursuit of a dream and knowledge, my suffering today has become a delight to the eye. Here I am today, my hard work has paid off, I stand at graduation raising my hat with pride. So, God, praise be to You, because You have enabled me to complete this success and achieve my dream...

And with all love, I dedicate the fruit of my success and graduation

To the One who adorned my name with the most beautiful title, to the One who supported me without limits and provided me without expectation. My first supporter in my journey, my strength, and my refuge after God, my pride and honor, my father.

To the one whose heart embraced me before her hands, whose prayers made hardships easy for me. To the compassionate heart and candle that was the secret of my strength and success on dark nights, my heaven, my mother.

To my dear grandmother, Ben Yahia Louiza, who embraced my childhood and raised me in her home, the source of tenderness and the keeper of my sweetest memories.

To the angels God blessed me with so that I could know the taste of a beautiful life through them, those angels who changed the concepts of love, friendship, and support in my life, my sisters.

(Merième, Douaa, Kaouther and Alaa)

To the one who provided me with strength and guidance, believed in me, and supported me in difficult times, the origin of what I am now. My soulmate, Ilham.

Finally, "من قال انا لها، نالها، وانا لها وان أبت رغما عنها أتيت بها، نلتها وعانقت مجداً عظيماً", here is the great day, the day I spent my arduous years of study dreaming of it until, by His grace and generosity, complete joy followed.

-Khaoula-

Dedication

After five years of fatigue and hardship in the pursuit of a dream and knowledge, my patience has now turned into joy shining in my eyes. Here I am today, my hard work has paid off, I stand at graduation raising my hat with pride. So, O Allah, praise be to You, because You have enabled me to complete this success and achieve my dream...

And with all love, I dedicate the fruit of my success and graduation

To the One who adorned my name with the most beautiful title, to the One who supported me without limits and provided me without expectation. My first supporter in my journey, my strength, and my refuge after Allah, my pride and honor, my father.

To the one whose heart embraced me before her hands, whose prayers made hardships easy for me. To the compassionate heart and candle that was the secret of my strength and success on dark nights, my heaven, my mother.

To the angels Allah blessed me with so that I could know the taste of a beautiful life through them, those angels who changed the concepts of love, friendship, and support in my life, my brothers.

(Amine and Amir Fares)

To my dear maternal aunts, Kirouani Hala and Kirouani Widad, who were never just aunts to me, but my twin souls — like sisters in tenderness and close friends in loyalty — and to their children, who were always a support and a joy that brightened my days and filled my heart with warmth and happiness

To the one who provided me with strength and guidance, believed in me, and supported me in difficult times, the origin of what I am now. My soulmate, Khaoula.

Finally, "من قال انا لها، نالها، وانا لها وان أبت رغما عنها أتيت بها، نلتها وعانقت مجداً عظيماً", here is the great day, the day I spent my arduous years of study dreaming of it until, by His grace and generosity, complete joy followed.

-Ilham-

ملخص

تستقصي هذه الدراسة التحول نحو المختبرات الافتراضية المتقدمة كحل تكميلي للتحديات التي تواجه التعليم التطبيقي التقليدي في الكيمياء الحيوية بجامعة فرحات عباس – سطيف 1، الجزائر. فبينما تظل المختبرات التقليدية ضرورية لاكتساب المهارات العملية الدقيقة مثل المناولة المخبرية والمعايرة والاستخلاص، فإنها تواجه قيودًا جوهرية تشمل التكاليف المرتفعة للمعدات، نقص المواد، المخاطر المرتبطة بالمواد الكيميائية أو العينات البيولوجية، وصعوبات لوجستية، مما يعرقل سير التجارب العملية وجودة التعلم. اعتمدت الدراسة المنهج الوصفي التحليلي من خلال تطبيق استبيان منظم على عينة مكونة من 100 طالب وطالبة من كلية علوم الطبيعة والحياة، لتقييم التجارب المخبرية، تحديد أبرز التحديات، واستكشاف مستوى تقبل الطلبة للبدائل الرقمية. أظهرت النتائج أن نقص التجهيزات المخبرية (47%) وارتفاع تكلفة الكواشف والتقنيات تمثل أبرز المعوقات. كما أبدى نحو 38% من الطلاب قبولًا مشروطًا للمختبرات الافتراضية وفقًا لمدى واقعية المحاكاة وتفاعليتها. وحدد الطلاب الخصائص المرغوبة للمنصة الافتراضية، والتي شملت الشروحات السمعية والمرئية (26%)، والدعم اللغوي الثنائي (عربي-إنجليزي) (21%)، والتجارب التفاعلية (20%). وأظهرت النتائج أيضًا تفضيل 69% من الطلاب لمنصة هجينة يمكن الوصول إليها عبر الموقع الإلكتروني والتطبيقات المحمولة، مع اعتبار سعر شهري يتراوح بين 1500 و2000 دينار جزائري مقبول. استجابةً لهذه الاحتياجات، تم تطوير منصة تعليمية رقمية متقدمة تدمج بين التعليم النظري والممارسات التطبيقية عبر مختبرات افتراضية ثلاثية الأبعاد (3D) مدعومة بالذكاء الاصطناعي. وتتيح المنصة للأستاذ تقديم الدروس المباشرة، مشاركة الفيديوهات والوثائق التعليمية، إدارة الأنشطة التطبيقية، ومراقبة تقدم الطلبة بشكل مستمر وتحليل أدائهم الفردي والجماعي عبر أدوات الذكاء الاصطناعي، ما يعزز فعالية التعليم والمتابعة الأكاديمية. تخلص الدراسة إلى أن نموذج التعليم المدمج، الذي يجمع بشكل استراتيجي بين المختبرات التقليدية والمختبرات الافتراضية، يمثل استراتيجية مجدية وفعالة من حيث التكلفة لتجاوز المعوقات القائمة. كما يعزز هذا النهج مرونة التعليم، إمكانية الوصول إليه، وفعاليته في التعليم التطبيقي للكيمياء الحيوية في السياق الجزائري، بما يتوافق مع أهداف التحول الرقمي الشامل للجامعة.

الكلمات المفتاحية:

الجامعات الجزائرية، الذكاء الاصطناعي، تعليم الكيمياء الحيوية، التعلم المدمج، التكنولوجيا التعليمية، تصور الطلاب، المخابر التقليدية، المخابر الافتراضية.

Abstract

This study investigates the transition towards advanced virtual laboratories as a complementary solution to the challenges facing traditional practical education in biochemistry at Ferhat Abbas University – Setif 1, Algeria. While conventional laboratories remain essential for acquiring precise practical skills such as laboratory handling, titration, and extraction, they face significant constraints, including high equipment costs, material shortages, safety risks associated with chemicals or biological specimens, and logistical challenges, which often disrupt experimental work and hinder learning outcomes. The study employed a descriptive-analytical approach through a structured survey administered to 100 students from the Faculty of Natural and Life Sciences, aiming to assess laboratory experiences, identify major challenges, and explore students' acceptance of digital alternatives. Results revealed that equipment scarcity (47%) and the high cost of reagents and technologies were the main obstacles. About 38% of students expressed conditional acceptance of virtual laboratories, depending on the realism and interactivity of the simulations. Key desired features for the virtual platform included audiovisual explanations (26%), bilingual support in Arabic and English (21%), and interactive experiments (20%). Additionally, 69% of students preferred a hybrid platform accessible via both a website and mobile applications, with a monthly subscription fee of 1500–2000 DZ considered appropriate. In response to these needs, an advanced digital educational platform was developed, integrating theoretical learning with practical applications through AI-enhanced 3D virtual laboratories. The platform allows instructors to deliver live lessons, share videos and educational documents, manage practical activities, and monitor students' progress continuously while analyzing individual and group performance through AI tools, thereby enhancing teaching effectiveness and academic follow-up. The study concludes that a blended learning model, strategically combining traditional laboratories with virtual laboratories, represents a feasible and cost-effective strategy to overcome existing barriers. This approach enhances flexibility, accessibility, and overall effectiveness in practical biochemistry education in Algeria, aligning with the university's broader digital transformation objectives.

Keywords: Algerian universities, Artificial intelligence, Biochemistry education, Blended learning, Educational technology, Student perception, Traditional laboratories, Virtual laboratories.

Résumé

Cette étude examine la transition vers des laboratoires virtuels avancés comme solution complémentaire aux difficultés rencontrées dans l'enseignement pratique traditionnel en biochimie à l'Université Ferhat Abbas – Sétif 1, en Algérie. Bien que les laboratoires conventionnels demeurent essentiels pour l'acquisition de compétences pratiques précises telles que la manipulation en laboratoire, la titration ou l'extraction, ils font face à des contraintes importantes : coûts élevés des équipements, pénurie de matériel, risques liés à l'utilisation de produits chimiques ou de spécimens biologiques, ainsi que divers défis logistiques qui perturbent souvent le déroulement des travaux pratiques et nuisent aux résultats d'apprentissage. L'étude a adopté une approche descriptive-analytique à travers un questionnaire structuré adressé à 100 étudiants de la Faculté des Sciences de la Nature et de la Vie, visant à évaluer leurs expériences en laboratoire, identifier les principaux obstacles et analyser leur niveau d'acceptation des alternatives numériques. Les résultats ont révélé que la rareté du matériel (47 %) et le coût élevé des réactifs et technologies constituent les principaux obstacles. Environ 38 % des étudiants ont exprimé une acceptation conditionnelle des laboratoires virtuels, dépendante du réalisme et de l'interactivité des simulations. Les fonctionnalités les plus demandées pour la plateforme virtuelle incluent des explications audiovisuelles (26 %), un support bilingue en arabe et en anglais (21 %), ainsi que des expériences interactives (20 %). Par ailleurs, 69 % des étudiants ont exprimé une préférence pour une plateforme hybride, accessible à la fois via un site web et des applications mobiles, avec un abonnement mensuel jugé adéquat entre 1500 et 2000 DA. En réponse à ces besoins, une plateforme éducative numérique avancée a été développée, intégrant apprentissage théorique et applications pratiques grâce à des laboratoires virtuels 3D améliorés par l'IA. Cette plateforme permet aux enseignants de dispenser des cours en direct, de partager des vidéos et des documents pédagogiques, de gérer les activités pratiques et de suivre continuellement les progrès des étudiants, tout en analysant leurs performances individuelles et collectives à l'aide d'outils d'intelligence artificielle, améliorant ainsi l'efficacité de l'enseignement et du suivi académique. L'étude conclut qu'un modèle d'apprentissage hybride, combinant de manière stratégique les laboratoires traditionnels et les laboratoires virtuels, constitue une approche réalisable et rentable pour surmonter les obstacles existants. Cette stratégie améliore la flexibilité, l'accessibilité et l'efficacité globale de l'enseignement pratique de la biochimie en Algérie, tout en s'inscrivant dans les objectifs plus larges de transformation digitale de l'université.

Mots-clés : Universités algériennes ; Intelligence artificielle ; Enseignement de la biochimie ; Apprentissage hybride ; Technologies éducatives ; Perception des étudiants ; Laboratoires traditionnels ; Laboratoires virtuels.

List of abbreviations

COVID-19: Corona Virus Disease – 2019

vLAB: Virtual Laboratory

VR: Virtual Reality

STEM: Science, Technology, Engineering, and Mathematics

e-learning: electronic learning

DNA: Deoxyribonucleic Acid

LMD: Licence – Master – Doctorat

ASJP: Algerian Scientific Journals Platform

PROGRES: Platform of Research and Higher Education Global Ressources and E-Services

PCR: Polymerase Chain Reaction

ELISA: Enzyme-Linked Immunosorbent Assay

DA: Algerian dinars

AC: Antibody

AG: Antigen

US: United States

USD: United States Dollar

List of figures

Figure 1. Different types of virtual labs.....	5
Figure 2. Setif-1 University – Ferhat Abbas: Location.....	18
Figure 3. Repeated Experiments in the Specialization.....	21
Figure 4. Repeating experiments periodically throughout the year.....	22
Figure 5. Most successful experiments.....	24
Figure 6. Experiments facing difficulties or high failure rates.....	25
Figure 7. Reasons for the discontinuation of some experiments.....	26
Figure 8. Experiments that students would like to see virtually.....	27
Figure 9. Expensive and hard-to-find materials.....	28
Figure 10. The most expensive equipment and technologies used in laboratories.....	29
Figure 11. Expensive reagents and materials used in laboratory experiments.....	31
Figure 12. The cost of one lab experiment per student.....	32
Figure 13. Experiments involving expensive powders and solutions.....	33
Figure 14. Average annual budget allocated to laboratories.....	35
Figure 15. Students perceptions of the usefulness of virtual experiments.....	36
Figure 16. Essential benefits of a virtualization platform.....	37
Figure 17. Preferred format of the virtual laboratory project.....	38
Figure18. Estimated value of a monthly subscription to the platform.....	39
Figure19. Challenges encountered in university laboratories.....	41
Figure20. Suggestions to improve the student experience in laboratory experiments.....	42

List of tables

Table1. Strengths and weaknesses of the different lab models.....	10
--	----