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University of Malta Courses with Intermediate / Advanced Chemistry as a Requirement and/or Option: An Analysis of Students' Choices

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Abstract

Tertiary course selection by post-secondary Chemistry students plays a pivotal role in shaping their academic trajectory across diverse fields [1]. Student decisions reflect a complex interplay of motivations and rationale, influencing not only their educational journey but also impacting curriculum design, pedagogical approaches, and support systems within Chemistry Education [2]. This study examines students' preferences, focusing on the University of Malta courses that have Intermediate (IM) or Advanced (AM) Chemistry as a requirement or option. Through distribution of self-administered questionnaires to stakeholders, this research study unveils themes derived from responses: influence, misconceptions, motivation, perception, career aspirations [3], acquired skills, and promotion of chemistry. [4] These themes shed light on converging and diverging viewpoints, offering insights into factors shaping students' decisions. Noteworthy results are student misconceptions about Chemistry, including perceiving it as difficult [5], underestimating its importance, and assuming limited career opportunities. The study underscores the significance of incorporating real-world applications of Chemistry in curriculum, advocating for practical examples, context-based approaches, and highlighting job opportunities to make the subject more relevant to students' daily lives. An often-overlooked aspect is the need for greater emphasis on promoting Chemistry as a standalone discipline. While Chemistry has served as a conduit to medical courses, its potential as an independent field is underappreciated, exacerbated by a lack of awareness and limited job opportunities. Consequently, students may explore alternative routes or consider options abroad [6]. The study reveals that having Chemistry at both IM and AM levels opens up a broader spectrum of career choices. University students highlight the role of personal aspirations and interests in motivating their decision to pursue a Chemistry-related course. While recognising factors such as University requirements, prestige, societal influences, and personal interests, sixth-form Chemistry teachers do not explicitly mention influence of personal aspirations in their key responses. Diverse career aspirations within the field of Chemistry emerge among University of Malta students. Despite this, there is a shared perception among university students that educational institutions inadequately promote Chemistry. These results could contribute to an informed and supportive framework for students navigating tertiary course choices in Chemistry.

Keywords: *Chemistry; University Courses; Enrolment; Tertiary Education*

1. Introduction

1.1 Aims of the Research Study

This study focuses on University of Malta (UM) courses featured in the Undergraduate Prospectus with Chemistry as a compulsory or optional requirement. It examines students' preferences and analyses UM course selection with Intermediate (IM) or Advanced (AM) Chemistry as requirements/options. The aim is to analyse student course preferences of students with IM and AM level Chemistry in their 1st, 2nd, and 3rd year of university. It investigates influences behind students' enrolment choices and their motivation to choose a university course with Chemistry as a compulsory or optional requirement. This research study explored whether Chemistry gives students wider career choices in the labour market. The two research questions were:

(i) RQ1: What are University students' motivation/reasons for selecting tertiary courses were IM / AM level Chemistry are specified?

(ii) RQ2: Does Chemistry at IM / AM level restrict student career options or does it open choices?

1.2 Literature Review

In higher education, student choices go beyond individual academic interests, creating a complex network of decisions that greatly affect their academic path [5]. The conceptual idea behind rational choice theory (RCT) shows students actively navigating many available courses as decision-makers. RCT proposes these choices are rational, shaped by personal preferences, beliefs, and limitations. Cultural background, commitments, and habits are key factors impacting student preferences [7]. Constraints on choices include academic requirements, enrollment limits, family duties, health issues, and physical restrictions [8]. Differences in evaluation among different students are further complicated by family income, social costs, and expectations.

Vocational Types Theory (VTT) and Social Cognitive Career Theory (SCCT) provide a theoretical understanding of students' choices. VTT focuses on personality types, categorizing chemists as investigative thinkers and realistic doers, illuminating the psychological aspects of career preferences [8]. Meanwhile, SCCT delves into the complex interplay between personal, behavioural, and environmental factors influencing academic and career decisions. SCCT highlights personal factors like self-efficacy and outcome expectations as crucial influencers. It also examines behavioural factors like actions students take to achieve academic and career goals. SCCT also considers environmental factors, including contextual and support elements that further shape the decision-making process [10]; [11]; [12]; [13].

1.3 The Educational System in Malta

The Maltese Education System is based on the British model. It is regulated by the Education Act of 1988 and subsequent amendments thereafter. Compulsory education ranges between 5 to 16 years of age, consisting of primary and secondary education. Students sit for 16+ examinations at Secondary Education Certificate (SEC) level on completion of their secondary education. This permits students to follow a vocational or academic route into post-secondary colleges and eventually continuue with their vocational or tertiary education. The tertiary institutions in Malta include the UM, the Malta College of Arts, Science and Technology (MCAST), the Institute of Tourism Studies (ITS), and a host of other local and foreign institutions, several of which representing oversees universities [14].

Students sit for 18+ Matriculation Certificate (MC) exams, which are entry requirements to university. The MC comprises six subjects and is awarded if students obtain passes in a language, a science and a humanistic subject, and a pass in a subject entitled ‘Systems of Knowledge’; students also need to score a minimum number of points based on their performance. Two of six subjects must be at AM level, three others at IM level, apart from Systems of Knowledge. Equivalent foreign qualifications are also accepted [15]. There are two Chemistry pre-university examinations: at IM and at AM level. These examinations are held biannually in May and September.

The UM’s student population has been recorded at 12,503 students for the academic year 2022/23. The selection of courses of interest for this study has been based on the UM undergraduate prospectus for academic year 2022/23. The University comprises of a total of 14 faculties and 18 institutes. There are a total of 20 courses within seven faculties which specify AM level Chemistry as an entry requirement or option. One of 18 institutes specify IM Chemistry as an entry requirement or option. Six of 14 faculties specify IM level Chemistry as an entry requirement or option. A total of 26 courses of interest were identified in the UM undergraduate prospectus which specify Chemistry as a potential entry choice [16].

The number of students enrolled in the 26 courses of interest in this study amounts to 5,118 from 2020-2022. Most students enrolled in these courses is attributed to Doctor of Medicine and Surgery (2,155) followed by the B.Sc. (Hons), and Built Environment Studies totalling 633 in 2020-2022. In certain courses (out of these 26), while Chemistry is one of the possible entry options, students may have other qualifications that make them eligible for enrolment. As a result, this study considered the students with an IM or AM level Chemistry qualification who enrolled in these courses. The total number of students was 667 (within a three-year period).

2. Research Methodology

2.1 Design

A mixed methods approach was adopted, consisting of two research instruments: the analysis of statistical data and three self-administered questionnaires to different stakeholders, namely UM students, Sixth Form Chemistry teachers and UM course coordinators. This approach allowed for the collection of quantitative and qualitative data, enabling a comprehensive analysis and understanding of the research aims [17]. Quantitative data provided numerical insights into patterns and associations, while qualitative data offered detailed descriptions and explanations of participants' perspectives.

2.2 Mapping the Participants

University students were sourced from those who had an IM / AM qualification in chemistry. They were in their 1st, 2nd, or 3rd year of study (enrolled between 2020-2022) and were enrolled in a course specified by the UM undergraduate prospectus for the academic year 2022/23. Students in their 4th and subsequent years of study were excluded because the decision to enrol in a university course would have been taken prior to the last three years, and a considerable amount of time would have passed to recollect their course enrolment decision. Sixth Form Chemistry teachers Chemistry in Maltese Sixth Forms were recruited. Course coordinators of UM courses with IM / AM Chemistry as a requirement or option were chosen.

2.3 Method

The online questionnaire consisted of 17 questions, divided into four sections (A-D): Demographics; Course Choices; Motivations and Reasons for Choosing Chemistry; and Students' Career Choices. The questionnaire was adapted to each stakeholder group. A piloting process was carried out on a small participant sample to pre-test the questionnaires for clarity, comprehension, and overall effectiveness. Data collection occurred between March and May 2023. Participants were contacted through the UM Registrar's office, social media and institutional websites. Convenience sampling was adopted, where participant selection was based on availability and willingness of participation in the study.

2.4 Limitations of the study

The study focused on students in their 1st, 2nd, and 3rd year of study who sat for the 2020-2022 MC sessions. It did not consider students who participated in multiple MC sessions, students enrolling through alternative entry requirements, or completing a course through alternative pathways to UM programs and applicants with foreign Chemistry qualifications. The perspectives of participants are based on their individual experiences. A larger sample size could have provided a more comprehensive exploration of students' views and experiences with IM and AM Chemistry qualifications regarding course selection.

3. Results

There were 107 participants in this study. They consisted of: 79 UM students (S1-79), 22 Sixth Form Chemistry teachers (T1-22), and six course coordinators (C1-6). Table 2 presents a summary of results.

3.1 University of Malta Students

A total of 79 responses were obtained (Table 1) from 106 student questionnaires. The distribution of respondents was as follows: 1st years (30.4%), 2nd years (40.0%), and 3rd years (31.6%). The three most popular courses were: Doctor of Medicine and Surgery (37 participants); B.Sc. (Hons) Chemistry (8 participants), and B.Sc. (Hons) Pharmaceutical Science (7 participants).

The responses were analysed using Braun and Clarke, 2006 [18]. The seven themes which emerged included: influence, misconceptions, motivation, perceptions, career aspirations, acquired skills and promoting Chemistry. The respondents were 47 females and 32 males. The most frequent motivations for choosing Chemistry were "family" followed by "teachers and mentors". One student stated: "The attitude and teaching methods of my teacher at Sixth Form were pivotal to developing a positive attitude to a subject" (S23). Other factors related to academic requirements. "Chemistry was always a subject I struggled with, and I only chose it because it was a requirement for pharmacy" (S79). "I definitely think that most students are [overwhelmed] by the idea of choosing Chemistry as it is made

out to seem [a] challenging subject" (S50). "I always enjoyed the subject [chemistry], but terrible teachers made it more challenging than it had to be" (S44).

Table 1. Student Participants

Course	Year of Study			Total
	1st Year	2nd Year	3rd Year	
B.Sc. (Hons) Information Technology (Computing and Business)			1	1
B.Sc. (Hons) Applied Biomedical Science	4	1	1	6
B.Sc. (Hons) Applied Food and Nutritional Sciences			1	1
B.Sc. (Hons) Biology	2	2	1	5
B.Sc. (Hons) Chemistry	1	4	3	8
B.Sc. (Hons) Medical Biochemistry		1	1	2
B.Sc. (Hons) Pharmaceutical Science	1	3	3	7
B.Sc. (Hons) Pharmaceutical Technology	2			2
B.Sc. (Hons) Pharmacology	1	1		2
B.Sc. (Hons) Podiatry	1		1	2
Doctor of Medicine and Surgery	9	15	13	37
Master of Dental Surgery	2	3	1	6
Total	24	30	25	79
Percentage	30.4%	40.0%	31.6%	100%

Other students comments were insightful: "Chemistry is not respected in Malta. No warrants, no real work other than 'analyst' / quality type jobs. Most successful chemists choose a completely different, higher-paying career path entirely" (S2). A high majority of 92.4% (73 of 79) participants stated that IM and AM level Chemistry widened their career choices. A total of 35 respondents (44.5%) indicated that they would consider a Chemistry-related career abroad. "I want to expand my horizons and work abroad" (S14). "Chemistry is a highly valuable subject anywhere in the world" (S16).

3.2 Sixth Form Chemistry Teachers

The responses of Sixth Form Chemistry teachers consisted of 10 female and 12 male respondents, all of Maltese nationality. They came from these educational sectors: state (54.5%), independent (27.3%), and church (18.0%) schools. They have a range of experience in AM Chemistry, spanning from two to 29 years, while IM Chemistry teachers' experience varies from one to 14 years. One Sixth Form college does not offer IM Chemistry. There are variations in teaching loads and class sizes. The number of AM Chemistry students varies, averaging between 60-70 students, with differences between institutions. Most respondents do not teach IM Chemistry, showing institutional differences, with others teaching a limited number of students.

The teachers perceived several factors influencing students' course choices, including university requirements, future career aspirations, prestige, societal influences, job opportunities, family background, personal interests, and peer influence. Teachers mentioned that students consider "professional opportunities" (T6) and "job satisfaction" (T11) when choosing their course. This resonates with the VTT where career choice and development and work satisfaction are emphasised.

Teachers focus on dispelling misconceptions about Chemistry, addressing perceived difficulty, comparisons with Biology, rote memorisation, and transition challenges. To support informed decisions, teachers stressed the importance of adopting an individualised approach, promoting exploration, and recommending students to utilise career guidance services.

Regarding student motivations for choosing Chemistry, teachers employ diverse strategies, including hands-on activities, diverse teaching resources, interdisciplinary connections, effective questioning, and maintaining a balance between theory and practice. Student motivations included career aspirations, interest in the subject, meeting prerequisites, exploring diverse career opportunities, and parental influence. Teachers incorporated context-based teaching, real-life examples, and implementing real-world applications to enhance students' understanding of the practical aspects of Chemistry.

Regarding students' career choices, teachers utilise various strategies, such as facilitating discussions, offering exposure, conducting research, sharing personal experiences, and collaborating

with career counsellors. However, teachers highlight a lack of information about job trends. “I feel nobody tells us anything and we are very much out of the loop, except from what we hear from ex-students. In-service courses should be designed specifically for Sixth Form teachers to help us guide our students better” (T2).

Teachers emphasised limited opportunities and stressed the need for enhanced promotion of careers in Chemistry. “… it does not make sense to promote a subject because the student knows that education is a means to a job … if the job is not well paid, does not have a high status, then the effort should be proportional” (T3).

Divergent opinions surfaced regarding the effectiveness of educational institutions in promoting Chemistry. Moreover, teachers expressed concerns about students' choices, highlighted restricted career opportunities, and advocated for increased promotion of Chemistry careers.

3.3 Course Coordinators

Despite reaching out to many course coordinators, the response rate and the level of engagement low. Thus, this limited cohort size may not fully represent the experiences and viewpoints. Some course coordinators dis not grasp the underlying focus of the study due to the presence of the term "Chemistry" in the questionnaire. This confusion arose as their specific course responsibilities did not did not directly involve Chemistry, although Chemistry is a potential entry requirement for their courses.

This study included insights from six course coordinators for a total of seven courses. The demographics showed a gender-balanced group, with three females and three males; all participants were Maltese nationals. Regarding Chemistry qualifications, four coordinators hold AM or IM Chemistry. In terms of teaching experience, they span from 15 to 37 lecturing years, with a mean of 27 years. Coordinator experience ranges from three to 15 years, averaging seven years.

Exploring students' course choices, coordinators identified factors aligned with the SCCT Model. These include: personal goals, job availability, salaries, personal preferences, and academic performance. Addressing misconceptions about Chemistry, coordinators emphasised practical applications and dispelled notions of difficulty and limited career options. They also stated that students' choice of IM or AM level is driven by interest, prerequisites, diverse career opportunities, and career aspirations.

Section D considered student career choices, where coordinators highlighted the role of Chemistry in understanding biological principles. Chemistry is perceived as contributing to interdisciplinary connections in the curriculum. “We wish to have students with knowledge in different subjects so that they may enrich [their experiences]” (C2). “Students acquire a good background in all the science areas and specialise in one. If they specialise in Chemistry this serves to give students an understanding of [the subject] in applied situations and in real-life contexts” (C5).

Recognition of Chemistry's impact on daily life was highlighted, with suggestions for improving curriculum emphasis. Students with a Chemistry background acquire analytical skills, data management abilities, research proficiency, logical thinking, and problem-solving skills “and an understanding of the application of principles” (C4).

The study also considered alignment with industry standards and expectations. Respondents stressed the importance of aligning Chemistry (as an entry requirement) with industry standards and proposed syllabus changes to include diverse real-world applications. Proactive industry engagement, in line with the SCCT model, involves close connections with the industry: “we are close to industry, and I regularly discuss the curriculum with industry exponents” (C6).

Additional comments included the the importance of basic Chemistry for all science students, even if not expressly a required prerequisite for Information and Communication Technology (ICT). The presence of Chemistry as an accepted AM level qualification, even though not taught in the course, helps students' potential career changes and choices. The rationale for limiting accepted AM levels to science subjects is to ensure a foundation in analytical thinking and problem-solving.

Table 2. Summary of Results

	Themes	University Students	Sixth Form Chemistry Teachers	UM Course Coordinators
1	Influence	- Family members - Teachers and mentors - Educational institutions - Career aspirations - Interest in the subject	- University requirements - Future career aspirations - Prestige and societal influence - Job opportunities and satisfaction - Family background and personal interests - Peer influence	- Personal goals - Job availability - Potential earnings - Personal preferences - Academic performance
2	Misconceptions	- Perceived to be difficult - Limited understanding of its applications - Limited career opportunities - Perception as a textbook science.	- Perceived to be difficult - Memorisation-based learning approach - Chemistry as a difficult subject compared to biology - Limited career opportunities	- Perceived to be difficult - Limited understanding of its applications - Limited career opportunities - Perception as a textbook science
3	Motivation	- Career aspirations - Interest in the subject - Future qualifications	- Career aspirations - Interest in the subject - Prerequisites for other programmes	- Career aspirations - Interest in the subject - Future qualifications
4	Perceptions	- Positive perception - Concerns about domestic vs. international opportunities	- Limited job market trends and opportunities in Malta. - Limiting career prospects (emphasis on medicine).	- Need for diverse career prospects in Chemistry - Limited advertising
5	Career Aspirations	- Broad options in career choices - Positive impact on future career prospects	- Varied options - Awareness of the relevance of Chemistry in real-world applications.	- Importance of lectures and teachers in emphasising the subject's relevance.
6	Acquired skills	- Career aspirations in Chemistry-related fields	- Academic skills in Chemistry - Analytical skills - Problem-solving skills	- Analytical skills - Critical thinking abilities - Practical laboratory skills
7	Promoting Chemistry	- Hands-on activities - Visual aids and analogies - Laboratory sessions - Discussions	- Hands-on activities and visual aids - Applying Chemistry to everyday life - Using humour - Incorporating questioning techniques and laboratory sessions - Importance of modernising the curriculum	- Promoting interdisciplinary knowledge - Complementary to other science subjects - Ensuring a solid foundation for further education.

4. Analysis and Discussion

4.1 Convergent and Divergent Perspectives

Career aspirations emerged as a crucial factor in course choices, resonating with both UM students and Sixth Form Chemistry teachers. Course coordinators added depth to this discussion by highlighting the significance of personal goals and job availability. In the field of Chemistry, participants recognised a variety of career aspirations, spanning medical professions, research, pharmacy, and

dentistry. The emphasis on aligning educational options and offers with students' career paths underscored the pivotal role of addressing these aspects in course design.

Both Sixth Form Chemistry teachers and course coordinators emphasised the paramount significance of integrating real-world applications of Chemistry into the curriculum. Proposals included practical examples, context-based approaches, and a spotlight on job opportunities. This shared focus on developing analytical skills, fostering problem-solving abilities, encouraging critical thinking, and emphasising practical applications underscores a collective commitment to showcasing Chemistry's practical utility.

In answer to RQ1, the study uncovered a disconnection between the views of university students and teachers on what motivates students to pursue chemistry. Students cited family influence as their main reason for choosing chemistry, while teachers indicated a complex web of factors including university requirements, societal impact, prestige, and personal interest as driving forces of students' course selection.

This misalignment purports student misconceptions about Chemistry being difficult, undervalued, and offering few career options. These concerns were shared by teachers and coordinators who aim to foster a more well-rounded understanding of the subject. UM students also identified a deficiency in the promotion of the subject by educational institutions. Conversely, Sixth Form Chemistry teachers expressed mixed opinions, suggesting a potential incongruency between students' expectations and institutional actions. This contrast shows the need for improved communication and awareness-building in order to bridge the gap.

The convergent and divergent perspectives illuminate the distinct viewpoints of UM students, Sixth Form Chemistry teachers, and course coordinators on influences, perceptions, motivations, career aspirations, and the role of Chemistry in education. These insights directly address the first research question regarding the motivations driving university students' selection of courses requiring IM or AM level Chemistry. RQ2 explored students' career options and the role of Chemistry as a limiting or expanding factor. The majority of students perceived Chemistry as a valuable qualification that widens their career opportunities, indicating a positive impact.

These varied perspectives emphasise the necessity for a nuanced approach in supporting students as they navigate course choices, recognising the intricate factors influencing their decisions. These results can contribute significantly to the development of a more informed and supportive framework for Chemistry education at the UM. The collaborative commitment to dispel misconceptions, align courses with career aspirations, and integrate real-world applications signals a positive trajectory for enhancing Chemistry education.

5. Conclusion and Recommendations

In conclusion, it is vital to identify and address students' misconceptions about the difficulty, perceived unimportance, and limited career prospects of the subject. Feedback from students, Sixth Form Chemistry teachers, and course coordinators revealed influences, perceptions, motivations, and career aspirations in Chemistry education. This understanding promotes stakeholder communication and decision-making, laying the groundwork for better educational practices.

The study advocates the integration of real-world applications into the curriculum, using practical examples, context-based approaches, and highlighting potential careers. This pedagogical shift would make Chemistry more relevant to students' daily lives, increasing their active engagement and success in related courses. The research insights are key for shaping future curriculum design, teaching methods, and support systems in Chemistry education. Incorporating these insights into educational practices is crucial for institutions to proactively boost student engagement, interest, and achievement in tertiary Chemistry courses. This study can help in creating a more comprehensive and engaging Chemistry education experience, to prepare students better for their careers and to advance in the field.

Further research can include a wider student body with such qualifications, ensuring a more comprehensive analysis of influences on course choices. To address the practical educational aspect , feedback from employers and workers with Chemistry qualifications could be incorporated into research methodologies. This will help with the alignment of academic programmes and industry

needs, ensuring graduates possess skills valued in the job market. A cross-cultural comparison on Chemistry choices would offer insights into the universality or uniqueness of factors that influence course selection. This will guide institutions in tailoring educational approaches to diverse student populations, and to foster inclusivity. Finally, a longitudinal study to analyse historical course selection data and to predict future trends would be useful. This approach empowers educational institutions to proactively adapt curriculum design, and ensure sustained relevance. Integration of these recommendations aligns with the overarching goal of advancing Chemistry education, deepening our understanding of course choices, and fostering student engagement and success.

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