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Breaking Down the Boundary Between High School and University Chemistry

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This study examined some of the factors that influence students' transition from Ontario high school chemistry to university introductory chemistry. The study was a mixed-methods, multi-phase research study carried out by an undergraduate honours thesis student who had experienced some of these transition issues. Students' transition into chemistry was reported to be more difficult than their overall transition into university, including their academic transition; they thus appeared to experience a "transition within a transition." Students identified testing, curricular experience, and the amount of independent work as the principal areas of misalignment between their high school and university chemistry experiences. In exploring the use of support resources, students reported that there were sufficient resource opportunities but typically did not avail themselves of one-on-one interactions. Analysis of the data has led to recommendations for the instructional team for Introductory Chemistry at McMaster University.

Introduction

Students proceeding from high school to university may be challenged by a variety of transition issues. This study explored the student experience during the transition from high school chemistry to university-level *Introductory Chemistry*, examining both curricular and non-curricular elements.

The transition into post-secondary level studies has been an important topic of research in recent years, in terms of the contributing factors that can affect the degree to which a student positively adapts to the post-secondary level environment (Wintre & Yaffe, 2000; Wintre et al., 2009). Some non-curricular factors that have been shown to influence a student's transition to the post-secondary environment include those related to the transition to a new learning environment, the transition to a new living situation (oftentimes a university residence or independent living in close proximity to the university campus), and increased independence, such as learning to budget time and money (Friedlander, Reid, Shupak, & Cribbie, 2007; Parker, Summerfeldt, Hogan, & Majeski, 2004; Wintre & Yaffe, 2000; Wintre et al., 2008; Wintre et al., 2009).

A number of factors related to high school academic performance or curricular experience have been shown to have an effect on the transition to post-secondary studies. Students report that post-secondary courses are fundamentally different from high school courses, both in

terms of pace and instructors' expectations (Conley, 2007). Not surprisingly, a student's high school grades are a strong predictor of academic success at the post-secondary level (Geiser & Santelices, 2007; Noble & Sawyer, 2002). Similar studies have demonstrated that the degree of academic success in high school chemistry correlates directly to the level of academic success in *Introductory Chemistry* at the post-secondary level (Beck & Davidson, 2001; Ogden, 1976). Research has shown that students' pre-existing (alternative) conceptions about scientific phenomena can interfere with students' future learning of correct scientific principles or concepts (Driver & Erickson, 1983; Palmer, 1999, 2001; Posner, Strike, Hewson, & Gertzog, 1982; Taber, 2000). Thus, chemistry concepts that may not be fully understood in high school can present significant learning barriers in university chemistry.

Through this study, we have discovered a 'transition within a transition;' namely, the students' experience of the overall transition into post-secondary education is perceived quite differently than the transition into *Introductory Chemistry* at McMaster University. Below we share data that support this notion.

Description of Methods

The subjects used for this study were students enrolled in *Introductory Chemistry* (CHEM 1A03) at McMaster University in the fall semester of 2011 (13 weeks of instruction, three hours of lecture per week; laboratories every other week). There were approximately 1,440 students enrolled in the course (at the time of the second survey). Three instructors were responsible for teaching the course, offered in four sections (two instructors each taught one section, and the third instructor taught two sections).

This project was conducted using a mixed methods approach over multiple phases. Phases 1 and 2 consisted of online surveys administered to *Introductory Chemistry* students. Phase 3 consisted of interviews with *Introductory Chemistry* instructors. Data from Phase 1 were used to help guide the development of some of the questions in Phase 2. Responses from the first two phases were then used when developing the interview questions for Phase 3. In the final stage of interpreting results, drawing conclusions, and making recommendations, the data from the three phases were combined (Johnson & Christensen, 2004).

The Phase 1 survey was administered in the first week of classes (September, 2011) in order to gather students' perceptions of their high school chemistry experience (e.g., assessment, laboratories, textbook use, etc.) before their exposure to university chemistry. Additionally, there were questions regarding non-academic aspects of their transition to university (e.g., living situation, job, stresses, pressures, etc.), and their expectations for and anticipations of *Introductory Chemistry* at McMaster. There were 202 responses, representing a 14% response rate (95% confidence level, 6.4% margin of error).

Phase 2 consisted of a second student survey at the end of the semester (November/December, 2011). This survey explored the students' perceptions of the *Introductory Chemistry* experience, with particular focus on transition issues relating to the high school to university transition, both academic and non-academic. As well, there was a series of questions regarding learning resources offered to *Introductory Chemistry* students. There were 172 responses, representing a 12% response rate (95% confidence level, 7.0% margin of error).

Both surveys had a combination of quantitative and qualitative questions. Demographic survey data analysis confirmed that the sample population was representative of the *Introductory Chemistry* population.

In Phase 3, 30-minute interviews were conducted with two *Introductory Chemistry* instructors. These interview sessions were used to gather information regarding the instructors' perceptions of students' transition into *Introductory Chemistry*. Further, interview questions were used to gather instructors' responses towards the areas where students' responses in the survey data suggested gaps or areas of difficulty. Interview sessions were held in February, 2012.

Results and Discussion

The three most significant themes that emerged from the data were those of transition experience, areas of misalignment (between high school chemistry and *Introductory Chemistry*) and use of resources in the course.

Transition experience

It is notable that while students mostly perceived their overall transition to university to be smooth, they were more likely to identify difficulty with their academic transition, and, within that, difficulty with their transition from high

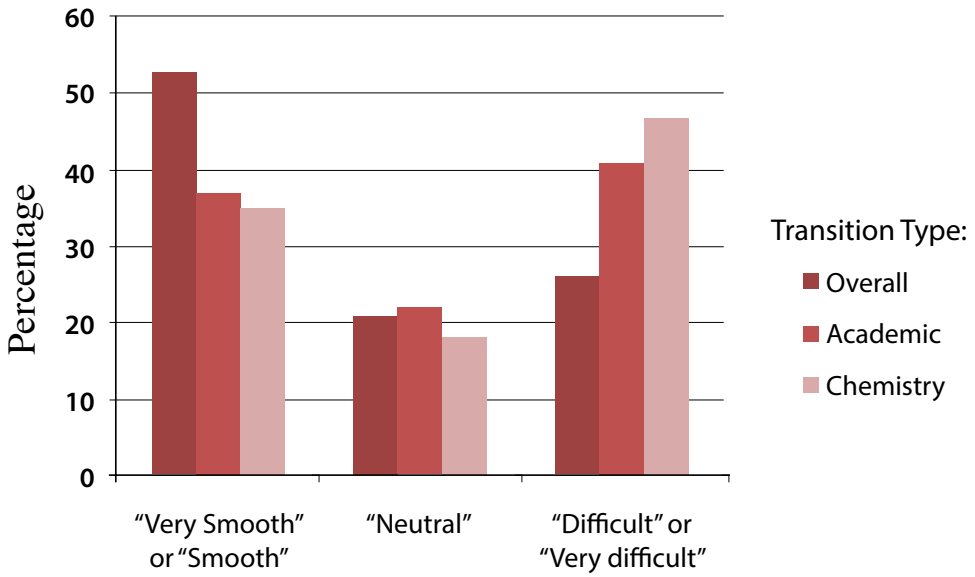

Figure 1

Students' indication of how smooth/difficult they found their high school to university transitions, based on three survey questions (Indicate how you found your (1)overall- (2)academic- and (3)chemistry transition from high school to university).

school to university chemistry (Figure 1). Thus, it appears as though students experience a transition within a transition. The idea of an academic-specific transition is supported by students' responses to the statement "your transition to university is affected by…" whereby the three factors most frequently identified were academic stress, a change in living conditions, and not feeling academically prepared.

Student and instructor perceptions differ with regard to how students experience the high school to University transition. Only 57% of students "agreed" or "strongly agreed" with the statement "My high school chemistry experience prepared me academically (in terms of chemistry skills and knowledge) to enter *Introductory Chemistry* at McMaster." Instructors, in contrast, held these views:

> *Overall students transition easily into [Introductory Chemistry] as a result of the overlap in content from Grade 12 chemistry, however, where students experience difficulties is more a result of the transition into university in general.*

> *Students arrive at [Introductory Chemistry] with diverse backgrounds and although the transition is a learning experience for them they learn relatively effectively and quickly and they do end up being able to transition well.*

Instructors thus hold the view that students' transition into *Introductory Chemistry* is less problematic than their overall transition into university, whereas students report the opposite view.

Areas of misalignment

Students and instructors identified three principal areas of misalignment between the high school and university experience in chemistry, namely, testing, curricular experience and the amount of independent work. However, these two groups approach these areas with different levels of expectation.

In the area of testing, students identified question wording, understanding how to approach questions and focusing on the correct answer as challenges. In their words,

> *Wording on midterms is strange and difficult to understand.*

> *I always feel like I know what I'm doing… until I open up the midterms and have no idea how to approach the questions.*

> *Conveying material in high school included being evaluated on the process we used. In university, it is only the final answer we achieve.*

Instructors also identify the challenge of wording questions clearly; however, one instructor reported that, from their perspective, "in chemistry we are fussy about making questions unambiguous [but]…it turns out to be very difficult." With regard to the idea of 'how to approach a question,' one instructor offered the viewpoint that, "[integrated questions] are a big mental barrier for [students] because they never expect to see questions that take on two different concepts." This instructor went on to share that university students often face questions that integrate multiple concepts, which is not typical of the high school approach. Further, students largely face these questions for the first time in university in a testing situation. This raises the following question: Why are students not exposed to the idea of integrating concepts before being expected to perform that function in a testing situation?

From their curricular experience the two strongest themes identified by students were the course workload and fast pace. In their words,

> *An immense range of topics and question types is covered in first year chemistry as compared to high school chemistry. The concepts build upon one another, making a snowball effect should you not understand one fully.*

> *[My most significant difference at University is] the freedom, workload, and pace.*

With respect to expectations of independent work, students illustrated differences from their high school experience with comments such as:

> *University tells you to teach yourself but high school doesn't.*

> *In high school I actually had to go to class, here I don't.*

> *[University has] more responsibility and freedom.*

> *I am alone and no one is checking up on me.*

Through these comments students identify a decrease in accountability coupled with a change in structure that may not fully support this change in accountability. Students arrive from high school with expectations based on their prior experience, only to find a structure that expects them to behave differently but does not sufficiently show them how. From the perspective of one instructor, "students can succeed very, very well…at learning the material...or without constant feedback from an instructor but it is a change for them and…that transition is a difficult one." The instructor further suggests that, "it's just a matter of getting them accustomed to learning on their own…being more independent…and self reliant." In this sense the student and instructor perspectives on the expectations for independence are in agreement, but neither offers a recommendation for how to bridge the gap.

Resource use

Students identified a number of resources provided in *Introductory Chemistry* that benefited their academic success, the most significant of which were pre-lab videos (shown in the lab and posted online) and previous years' midterms. Students reported additional valuable resources, such as online lecture notes, an online homework system, and weekly problem sets. Students recommended that the resources be expanded to include weekly lecture reviews and small study groups.

In stark contrast, when students were asked about the resources where they would attend in person, a vast majority reported that they "rarely" or "never" attended the drop-in help centre (91%), instructors' office hours (72%) or tutorials (59%). However, a majority of students (76%) did "strongly agree" or "agree" that enough resources for acquiring help in *Introductory Chemistry* were offered. This leaves an unanswered question: Why do students tend to not attend the 'in-person' help opportunities? Arguably these are the resources that may most closely replicate the level of personal attention available to students in high school, given the large class environment in a university course. One final student comment highlights the desire for personal interaction:

> *Not having the chance to really understand a concept by conversing with students or teachers easily. The lack of 'in-class' work really hinders my ability to understand or even know if I understand, as I often feel more prepared than I really am.*

This raises another question about resources: Given a desire for interaction with peers/instructors yet low attendance at the 'in-person' resources, could a different offering of resources meet student needs more effectively?

Recommendations

Based on the evidence collected in this study, a number of recommendations for the *Introductory Chemistry* instructional team emerge.

With respect to resources, the authors recommend introducing weekly lecture reviews; more frequently distributing work for which students are accountable; providing help with studying for, and practicing, multiple choice questions; and encouraging attendance at the in-person resources by explicitly emphasizing the importance and value of seeking one-on-one help to address misconceptions. Instructors are also encouraged to connect with other organizations within the university to take advantage of existing resources (e.g., time management seminars).

With respect to transition issues, the recommendations to instructors are to discuss openly with students the fast pace of the course and the amount of material to be covered, but also to remove some course content. Additionally, instructors are encouraged to create opportunities for students to practice questions that integrate multiple concepts before introducing such questions in a testing situation. Many of the above points support the idea of creating more 'scaffolding' (structure of accountability) for students.

This study focused primarily on the context of *Introductory Chemistry* at McMaster University and our discussion and recommendations reflect this; however, notions conveyed in this essay can be modified and applied for other disciplines, particularly in the area of science.

Future questions to be considered would be to explore why students use some resources more than others, why they do not attend the in-person resources, and what new resources could be developed to meet student needs.

Concluding Remarks

Students transitioning from Ontario high school chemistry into *Introductory Chemistry* at McMaster University face a variety of transition issues. These issues range from factors affecting their overall transition to university to highly course-specific factors impacting their experience and academic success in *Introductory Chemistry*. The results and recommendations from this study will be disseminated to the instructional team for their consideration, with the goal of offering an evidence-based structure to facilitate a more successful transition into *Introductory Chemistry* at McMaster University.

Undergraduate Research Project

This research project was initiated by the first author of this paper who at the time of the research was a Level 4 undergraduate honours Life Science thesis student at McMaster University and had experienced some of the effects of the transitional boundary between high school and university. The goal of this work was to develop evidence-based recommendations to offer to the *Introductory Chemistry* instructional team so that they might break down some of the boundaries that exist between high school and university chemistry and facilitate the transition process for students studying chemistry at McMaster.

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Biographies

Natashia Cunningham graduated from McMaster University in June 2012 with an Honours B.Sc. (Life Science). She is currently undertaking a second degree in French at McMaster.

Kris Knorr is an educational developer at McMaster University's Centre for Leadership in Learning. His research interests include transitional issues for incoming post-secondary students and factors associated with faculty development participation.

Pippa Lock is an Assistant Teaching Professor and the Associate Chair (Undergraduate Studies) in the Department of Chemistry and Chemical Biology at McMaster University. Pippa is a 2009 recipient of the President's Award for Instruction.

Sue Vajoczki (1966-2012) was a Teaching Professor in the School of Geography & Earth Sciences and the Director of the Centre for Leadership in Learning at McMaster University. Sue had been the recipient of numerous teaching awards; most recently she was named a 3M National Teaching Fellow.