“Everything is in the Lab Book”:

The Role of the Lab Book Genre in Writing, Knowledge-Making, and Identity Construction in Academic Medical Physics Labs

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Abstract

This qualitative study explores the nature and functions of the lab book genre in the discipline of medical physics. Specifically, it investigates how the multimodal nature of the lab book facilitates knowledge-making and identity construction in an academic medical physics community located in a Canadian university. The study employs the theoretical framework of Writing, Activity, and Genre Research (WAGR) in combination with the theoretical notions of communities of practice (CoP) and multimodality. The data collected include observational field notes, multimodal lab books collected from, and semi-structured interviews conducted with, five participants with a range of experience in the academic medical physics community. Findings of the study indicate that the lab book, particularly its multimodal features, serves as an important knowledge-making artefact within the medical physics community. The genre is found to perform multiple roles, including, but not limited to, providing a means of reifying experimental results and a space for community members to participate and negotiate their professional identities within the discipline of medical physics. Implications for further research of the nature of knowledge in medical physics, as well as implications for multimodal genre analysis, are discussed.

Keywords: activity theory, identity, knowledge construction, lab book, medical physics, multimodality, rhetorical genre studies, WAGR

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Interview and Member Check Codes

Dr. Britney

Interview 1: Br_INT1_July9

Member Check: Br_MC_February2

Professor Burke

Interview 1: B_INT1_July9

Dr. Lee

Interview 1: L_INT1_July25

Professor Poole

Interview 1: P_INT1_August19

Member Check: P_MC_December18

Sean

Interview 1: S_INT1_July21

Member Check: S_MC_December11

Glossary

Activity System: The unit of analysis in activity theory, defined as "any ongoing, object-directed, historically conditioned, dialectically structured, tool-mediated human interaction" (Russell, 1997, p. 510).

Addressivity: "The quality of being directed to someone" (Bakhtin, 1986, p. 95). In this case, addressivity is connected to the notion of genre as all genres are written for a particular audience.

Activity Theory: AT; a theoretical lens examining tool-mediated human activity (Engeström, 1999).

C(A)T: Computerised (Axial) Tomography; an imaging technique where multiple x-rays are taken from different orientations to create a three-dimensional rendering of a patient.

CoP: Community of Practice; a group of individuals with shared goals, resources, and norms (Wenger, 1998).

CRU: Canadian Research University, a mid-sized Canadian University and the site of this study.

DICOM: Digital Imaging and Communication in Medicine; a standard for storing, transmitting, and using medical images such as scans and x-rays.

Dosimetry: A field in medical physics that aims to "[quantify] the amount of radiation absorbed in volumes of tissue" (Köster et al., 2013, p. 566) in the human body to ensure accurate radiation doses are given to patients during radiation therapy treatments.

Exigence: An "objectified social need" (Miller, 1994, p. 26) that calls for a particular rhetorical response.

Genre Ecology: "An interrelated group of genres…used to jointly mediate the activities that allow people to accomplish complex objectives" (Spinuzzi & Zachry, 2000, p. 172).

Modal Complexity: The ways in which a variety of modes are linked together to perform activity, contributes to modal density (Norris, 2004a).

Modal Density: The combination of modal intensity and complexity to achieve high-level actions (Norris, 2004a).

Modal Intensity: The importance a mode has in an interaction; the higher the intensity, the more necessary the mode is to the interaction (Norris, 2004a).

Mode: A semiotic tool (Kress & van Leeuwen, 2001); that is, a symbolic resource that may be visual, textual, numerical, which enables its user to create meaningful representations of reality.

Monte Carlo: Techniques that are based on algorithms that calculate and predict, for instance, the direction of photon beams, the scatter of beams, and the number of beams to reach a simulated patient.

MRI: Magnetic Resonance Imaging; an imaging technique that uses magnetic waves to produce scans of a patient.

Participation: An active process that describes "the social experience of living in the world in terms of membership in social communities and active involvement in social enterprises" (Wenger, 1998, p. 55).

PET: Positron Emission Tomography; an imaging technique in nuclear medicine where a patient is injected with a small dose of radioactive liquid that locates tumour growth or weak cardiac muscles, for example.

PeTrack: Positron emission Tomography tracking; research examining how patient motion can be tracked during PET scans. This technique should allow technicians to correct for and sharpen scans blurred by patient movement.

PeTracker: A small radioactive marker used to track the movement of a patient, tumour, etc., during a PET scan.

Reification: A process that materialises abstract notions, tools, and concepts of a community through its members' participation within it (Wenger, 1998).

Rhetorical Genre Studies: RGS; a conceptualisation of genre that examines recurrent texts as actions responding to and recreating recurrent social situations (Miller 1994/1984, Paré & Smart, 1994).

Social Situation: A socially defined situation that determines how members of a particular community create, draw upon, and further develop particular genres and how genres create and evolve communities in which they are found (Miller, 1994; Paré & Smart. 1994).

Utterance: A link in a chain of communication (Bakhtin, 1986).

WAGR: Writing, Activity, and Genre Research; a theoretical framework integrating the theoretical notions presented in AT and RGS (Russell, 2009; Spinuzzi, 2010).

Chapter One: Introduction

In the middle of our interview, I ask Sean about a conference proposal that he has shown me to help illustrate his explanation about his research with a local cardiovascular centre. He brings up his lab book again, more specifically how the lab book helped him write the proposal. When I ask him about the lab book's role in developing texts like conference proposals, he picks up one of the two blue-covered, bound notebooks that he has brought with him to our interview. He opens the book and flips through the pages before he finds the entry that he is looking for. Sean turns the lab book so that I can read the entry and points to a lined page. It's filled with technical-looking sketches and notes, both scrawled in pencil. "When we went to the hospital to do this scan, this*,"*[1] *he tells me, pointing to the various notes and drawings, "is what I wrote. So, on April first, it's very messy, but for me, that's everything I needed to know. This was the first scan, so I wrote where we placed the markers, I took a picture, wrote down the numbers I needed. Everything during the experiment that I needed that wouldn't be recorded by a computer, I put it here*." (S_INT1_July21)

The above passage is a note that I took during an interview with Sean, a medical physics doctoral student entering his final year of doctoral studies and one of the participants in my research (for more information about participants see Chapter Four). The passage is striking to me for several reasons. Not only was I *not* expecting Sean to relay the necessity of a lab book in writing important texts like proposals for conferences, I also was not expecting to hear him say that "everything he needed to know" was in the

[1] All interview data have been edited for false starts, repetition, and verbal tics.

lab book. In addition, I was surprised that Sean’s instinct was to bring not one, but two of his lab books with him to the interview; a fact I neglected to notice until the incident described above. Incidents like these were extremely common during the data collection stage of this study, and each time a participant brought up how she or he used her or his lab book, I was struck by the ubiquity of this text-type.

The present qualitative study developed out of two areas of interest: the first being the nature of writing in the natural sciences, the second being way in which texts within the natural sciences often include visuals and mathematics, as well as writing (i.e., these texts are *multimodal*). At the outset of this study, I was interested in examining how the coordinated forms of typified and recurrent rhetorical actions, or *genres* (see Chapter Two for a more detailed discussion), were produced and disseminated in order to create knowledge in the discipline of medical physics. In particular, I initially hoped to take a constructivist viewpoint, that is, examining how writing in particular contributes to socially generated and maintained ways of creating meaning and knowledge (e.g., Bruffee, 1987; Witte, 1992), to examining the creation and distribution of medical physics knowledge claims. As such, I expected to be analysing conference papers, dissertations, and journal articles produced within medical physics.

This assumption arose from the many explorations into how knowledge is socially constructed, in particular through writing, in a variety of academic disciplines (e.g., Blakeslee, 1997; Emerson, 2011; Wickman, 2013; Winsor, 2003). Of particular interest to knowledge-making work is the genre of the academic journal article. Numerous scholars have examined how journal articles in the natural and physical sciences are involved in the disciplinary construction of knowledge (e.g., Bazerman, 1988; Graves,

2005; Myers, 1985a). Such studies have provided insight into how discipline-specific writing impacts the construction of knowledge claims that are subsequently distributed amongst many members of the discipline to be debated or drawn upon as valid claims.

In addition to knowledge construction, writing has also been viewed as playing a role in the formation of the identities of members of a particular community. Emerson (2011), for instance, demonstrates how writing, not only for journal articles but also for popular science and even for non-science texts, engaged professional academic scientists as members of their field. Blakeslee (1997) too alludes to how writing the texts for a specific scientific discipline helps new members of the community develop their identity within the field.

Recently, explorations into the nature of writing in the natural and physical sciences have increasingly found that technological advances, which enable scientific research, have made examining non-textual representations in scientific genres as important as examining the text itself (e.g., Wickman, 2013, 2015). This is particularly noteworthy because, as I discuss in more detail below (see Chapter Three), the discipline of medical physics relies heavily on the use of new technologies, such as simulations, digital databases, and digital images (Coopmans, Vertesi, Lynch, & Woolgar, 2014, p. 1), in order to accomplish knowledge-making goals. The technological advances in natural and physical science disciplines have consequently necessitated the examination of linguistic, numerical, and digital and simulated visual representations to understand the knowledge-making practices within scientific disciplines (e.g., Coopmans, Vertesi, Lynch, & Woolgar, 2014). Examining the interconnection of a number of different means of symbolic representation (e.g., written, visual, mathematical), that is, examining the

multimodality (see Chapter Two) (Kress & van Leeuwen, 2001), inherent in a number of genres found in the natural sciences has led to insights into the accepted ways of making and distributing knowledge claims (e.g., Myers, 2014; Wickman, 2013).

As I alluded to above, while there is a growing body of research investigating the multimodal nature of writing in the natural sciences, there is a dearth of knowledge concerning genres that act “behind the scenes”. While there have been some investigations into hidden genres, such as Myers’s (1985b) investigation into grant and funding proposals in biology, there are fewer still investigations into the genre of the lab book. Even in the existing investigations, lab books are not necessarily analysed for their role in knowledge construction, but tend to be discussed in terms of how this type of text may be used by science educators in their classrooms (e.g., Hanauer, Hatfull, & Jacobs-Sera, 2009). This is noteworthy because through the emergent design of this study (see Chapter Four) I quickly realised that the lab book was a seminal part of how the conference papers, dissertations, and journal articles came to exist in the first place. Lab books, it seemed, were too important to overlook in a study examining knowledge construction. While Wickman (2010, 2013) does analyse how lab books are used as knowledge-making objects in the discipline of chemical physics and does examine the role of visual representation in knowledge work, to my knowledge, these studies stand alone in the field of writing studies. In addition, there exists little to no research about the genres used in medical physics specifically, a noteworthy field due not only to its interdisciplinarity, but also due to its position within the general physics community (B_INT1_July9).

This study aims to examine how the medical physics lab book is implicated in the knowledge-making work of the disciplinary community, while paying special attention to the multimodal nature of the lab book. To this end, I am guided by the following questions:

1. How does the genre of the medical physics lab book facilitate the knowledge-making work of the medical physics community?
2. How does the lab book facilitate discipline members' professional identity construction and maintenance?
3. How does the multimodal nature of the lab book facilitate both the knowledge-making work of the medical physics community and the identity construction and maintenance of its members?

I argue in this study that the lab book functions as a necessary and central artefact in both knowledge and identity construction through its multimodal nature as a means of allowing medical physicists to both participate within and construct knowledge within their field.

This investigation begins with an overview of the theoretical and analytical approaches (Chapter Two) I draw on to address the research questions presented above. Here, I introduce the theoretical constructions of activity theory (AT), rhetorical genre studies (RGS), as well as how I conceptualise the field of medical physics as a community of practice (CoP) engaged in producing multimodal texts. Chapter Three outlines a brief review of previous literature examining discipline specific writing, the role of discipline specific writing in constructing knowledge and constructing disciplinary communities, and finally how multimodality has been integrated in research examining

writing in the natural sciences. Chapter Four details the methods used (i.e., the research site and participants, data collected, and the unit and method of analysis) in this study. Chapter Five presents the analysis of interviews and its findings and discusses the lab book’s role in the medical physics community, which is followed by a discussion of what the findings mean in terms of knowledge and identity construction in medical physics (Chapter Six). Finally, Chapter Seven summarises the conclusions this study draws, as well as its limitations and implications for explorations of writing in natural sciences and for future research in the field of writing studies.

I begin by introducing the theoretical framework of this study. This framework integrates AT and RGS in order to examine writing as a key tool in the kinds of activities that go on in medical physics, such as researching and teaching. In addition, AT and RGS are further complemented by Wenger’s (1998) notion of CoPs and by the theoretical construction of multimodality.

Chapter Two: Theoretical Framework

In this chapter, I present an overview of the theoretical framework that informs both the data analysis and discussion of the findings of this study. Particularly central to the construction of the theoretical lens underlying this thesis are the notions of activity and of genre. When I write about activity, I use the term to refer to *mediated, human action* that is embedded in a larger *collective activity* (Engeström & Miettinen, 1999). That is, I view activity as being mediated, or accomplished with the aid of symbolic (e.g., abstract linguistic) and material (e.g., physical objects, like pen and paper) tools. These tools are brought into and facilitate the actions of individual humans, who work within a larger group (the collective) to accomplish shared and more abstract goals. This particular conceptualisation of activity has been developed within the framework of AT, which theorises the nature of collective human actions (e.g., Engeström, 1987, 1999; Engeström & Miettinen, 1999). AT is often used to examine how mediational artefacts, such as texts, are taken up in the actions of human individuals within a collective, in addition to how tools mediate the actions of the group.

The notions of mediation and mediating artefacts are central to this thesis, and genre as a mediating artefact is particularly important. The approach to genre that I adopt in this study is a socio-cultural one that views genres as typified and social responses to recurring social situations (Miller, 1994). This particular approach to genre is known as RGS (e.g., Bawarshi & Reiff, 2010; Bazerman, 1994; Freedman and Medway, 1994). In essence, this view of genre conceptualises types of texts as being created for a specific purpose, within a specific context, for a specific group or audience. Additionally, since these genres are embedded within specific contexts and used for specific purposes, they

reflect not only the ideologies of the group in which they are found, but also influence the practices of these groups (e.g., Paré & Smart, 1994; Smart, 1998).

Several scholars have found that combining the theoretical notions of activity and genre from AT and RGS, respectively, have led to insights into not only the nature of writing within particular communities, but also into how writing may be used as a mediational tool to accomplish goals within a community (e.g., Russell, 1997). In this study, I adopt a version of activity-based genre research, wherein a cultural-historical (i.e., situated and bound in both the past and current practices and beliefs of a particular group) approach to examining the nature of human activity is combined with RGS (e.g., Russell, 1997; Smart, 1998; Smart, 2006; Smart & Brown, 2006; Spinuzzi, 2003). The integration of the theoretical construct of activity as collective and mediated through both symbolic and material tools with the notion of genre as social and rhetorical action creates a “powerful analytic frame for investigating the socio-cultural contexts within which writing is situated” (Smart & Brown, 2006, p. 245). That is, the frameworks of AT and RGS may be considered complementary because writing and discourse can be conceptualised as symbolic tools that enable action within networks of activity.

More recently, the integration of activity and genre has led to the development of the theoretical framework that Russell (2009) and Spinuzzi (2010) call Writing, Activity, and Genre Research (WAGR). The integrated conceptual and analytical framework of AT and RGS provided by WAGR allows me to view the repeated, historical, and ideological discourses used in medical physics, such as the lab book, as symbolic tools. In addition, WAGR enables me to trace the various roles that the lab book takes in the knowledge-making activities of medical physics labs. This analytical framework, when

combined with the theoretical notions of CoP (Wenger, 1998) and multimodality (Kress & van Leeuwen, 2001; Norris, 2004a), allows for the interpretation of how the multimodal nature of the lab book contributes to the knowledge-making goals of the medical physics community.

In this chapter, I begin by discussing the two theoretical lenses in WAGR: AT and RGS. A brief history of the development of AT from a means of explaining how symbolic tools mediate responses to outside stimulus to its current aim of interpreting collective, tool-mediated activity is presented. This is followed by a discussion of how AT is applicable to this study. A discussion of the second major theoretical construct embedded in WAGR, RGS, is also presented. The main theoretical tenets of RGS are discussed, as are their application to this study. In addition to the main theoretical tenets of AT and RGS, I provide a brief description of how the two theories work together in the analytical framework of WAGR. I then briefly overview of the theoretical notion of CoP, followed by a brief description of the theoretical conceptualisation of multimodality that I adopt in this study.

Activity Theory

As I briefly mentioned at the beginning of this chapter, AT views activity as collective and mediated, essentially meaning that human action is facilitated using tools in order to satisfy a goal within a group (Engeström, 1987). In order to “map out” human activity, AT uses the activity system (AS) as its unit of analysis (see Figure 2.1). These activity systems may be defined as “any ongoing, object-directed, historically conditioned, dialectically structured, tool-mediated human interaction” (Russell, 1997, p. 510). The ongoing, historical, and dialectical nature of the AS demonstrates the

cultural-historical nature of AT. This is because the AS is not only historically and culturally rooted in the practices of a specific community, but also tool-mediated and bi-directional (i.e., the AS influences the community and vice versa) (Russell, 1997). Below, the basic components of an AS are presented and explained using the example of how the lab book in medical physics may be used to facilitate mentoring (for further discussion, see Chapter Five). The nodes (see Figure 2.1) present within an activity system as described by Russell (1997) are:

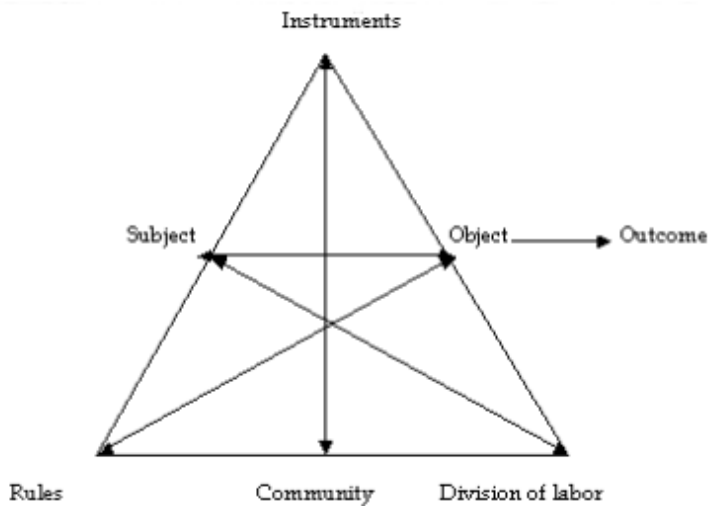

Figure 2.1. Activity system. This figure illustrates an activity system based on Engeström's (1987) expanded representation of human activity (Kärkkäinen, 1999).

- The subject, which is the agent of the action or behaviour being focused on in the analysis. For instance, a professional academic medical physicist could occupy this node; in which case, it would be her or his action that the analyst is tracing;
- Tools or mediational artefacts, which refer to symbolic and "material objects in use by [the subject] to accomplish some action with some outcome" (Russell, 1997, p. 511). Mediational artefacts can be

conceptualised as tools brought into the use of an individual or group. For example, the lab book may act as a mediational tool that the professional academic medical physicist brings into her or his action;

- The object, which refers to the thing or idea being acted *upon* with the mediational artefact. In my example, the object is a medical physics student learning the ways of knowing and doing in her or his field by a professional academic medical physicists, who is in turn using the lab book as a mediational artefact to teach the student about the field;
- The outcome, which is why the subject is acting in the first place. In the medical physics example, the outcome may be to teach students the proper procedures for keeping a lab book and, consequently, the kinds of knowledge and procedures valued in the discipline.

An AS is used as a heuristic in order to trace local activity, which is a concrete activity that draws upon "historically formed mediating [artefacts and] cultural resources that are common to the society at large" (Engeström & Miettinen, 1999, p. 8). That is, local activity is represented in an AS, where social artefacts are used in order to accomplish particular goals. Local activities, moreover, can be linked with another AS to trace how different activities may be connected to each other. The AS depicted in Figure 2.1 is a representation of local activity. This particular representation evolved through three generations of AT.

First generation AT developed out of Vygotsky's notions of actions being mediated by cultural tools and signs (Engeström & Miettinen, 1999). Vygotsky's work, though technically not AT, influenced the development of subsequent versions of the

analytical framework (Engeström & Miettinen, 1999, p. 4). Originally, Vygotsky aimed to explain how humans used *conceptual, symbolic* artefacts in order to facilitate higher mental functions (Vygotsky1986). That is, Vygotsky’s main purpose in his discussion on mediated actions was theorising how human individuals employ abstract and psychological tools, like language, in order to create a response to satisfy a particular situation (1986).

Notions of mediated actions were taken up by students of Vygotsky, specifically Leont’ev (Sannino, Daniels, & Gutiérrez, 2009), who developed the second generation of AT. Although this particular version of AT grew out of Vygotsky’s work, instead of being concerned with individuals and individual activity, Leont’ev argued that AT could be used to theorise about *collective* activity. In this particular version of AT, as Engeström (1987) writes, it is possible to “speak of the activity *of the individual,* but never of *individual activity* [emphasis in original]” (p. 84). In other words, while individuals may perform actions by themselves, they do so in orchestration with a larger group. In this way, the activity of the individual is closely connected with the collective’s activity.

In addition, second generation AT shifted away from being solely concerned with the examination of how humans use symbolic and conceptual tools, and instead also recognised the function of *material* tools, or artefacts, in human activity (Engeström, 1987). That is, material artefacts, such as pencils and paper that are used in writing, became viewed as equally important to symbolic linguistic artefacts. The *subject* of Vygotsky’s original formulation was now seen as a member of a larger collective who was able to draw on both symbolic and material tools that became known as *instruments*

that were used on particular *objects* to achieve a specific *outcome* (Russell, 1997). The important shift that took place in this particular generation was Leont’ev acknowledging that while symbolic tools may play very important roles in human activity, just as important are the material tools that humans draw upon to accomplish actions (Artemeva, 2006). The notion of mediational artefact being expanded to include material objects helped set the stage for examining all kinds of human activity, from the abstract and symbolic to the concrete and material. In addition, Leont’ev developed a triadic representation of human activity, called an activity triangle, as a heuristic to map out human actions.

The second generation of AT was further expanded through Engeström’s (1987) work examining how AT might be used in teaching. Engeström’s contributions to third generation AT preserved the idea of individuals acting in a collective as well as the notion that mediating instruments could be either symbolic or material, but began to take into account the nature of the collective. He expanded Leont’ev’s triadic heuristic to interpret not only the structure of activity, but also how activity is “transformed into consumption and subordinated to the three dominant aspects of human activity – production, distribution and exchange (or communication)” (p. 94). That is, the expanded version of AT provides a heuristic to map how the outcomes that are produced as a result of activity, as well as how the activity itself and the division of labour within it, are distributed amongst a specific community. In addition, the heuristic maps how rules of the community influence the exchange of symbolic and material goods produced by an activity and how the rules may govern the activity taking place.

In addition to the expanded activity triangle system that mapped how an individual’s or group’s mediated action is bound by a specific community, its rules and conventions, and its division of labour (Engeström, 1987), the main difference between third generation AT and previous generations of the theory is its concern with the interactions and contradictions within and between activity systems, in addition to contradictions within an individual node of an AS (Spinuzzi, 2003). Engeström (1987) discusses four contradictions that may occur within one central activity system, that is, the main system under investigation:

> Primary contradictions, referring to a contradiction within a single component of a central activity;
>
> Secondary contradictions, referring to tensions or contradictions between constituents of a central activity (e.g., between the instrument and object);
>
> Tertiary contradictions, referring to tension between the outcomes of a dominant form of central activity and more culturally advanced central activity, and;
>
> Quaternary contradictions, referring to tensions between a central activity and “neighbouring activities”. (pp. 103-104)

The notion of contradiction within and between activity systems is significant because contradictions can lead to new ways of accomplishing or performing an activity, as well as the development of new activity systems.

There are several benefits of approaching AT from a third generation perspective in my study. First is my ability to trace the connections that exist between different activities in the medical physics community. Additionally, AT enables me to trace how the cultural artefacts within this community either facilitate actions or create tensions

within and between activity systems. AT recognises that local activity draws on such cultural resources as mediating artefacts, and third generation AT is particularly useful in tracing how artefacts are adapted and transformed in networks of activity systems (Engeström & Miettinen, 1999, p. 8). That is, by examining networks of activity systems, it is possible to trace how cultural resources are activated in different, but still connected, activities. This generation of AT more accurately recognises the dynamism and interconnectedness of activity within a specific community (Engeström, 1987). This is especially important for this study because WAGR combines AT with RGS, which recognises genres as being dynamic and inherently connected to the communities in which they are found.

Rhetorical Genre Studies

In this study, I employ RGS as another theoretical lens (Bazerman, 1994; Miller, 1994; Schryer, 1993). Before delving into a more in-depth discussion of RGS and its role in this study, I define the notions of social situation, exigence, and addressivity. The conceptualisations of these three notions are central to the understanding of genre that I draw upon in this paper.

One of the key tenets of the theoretical construction of genre that I employ in this study is that of a *recurrent social situation*. The notion of social situation grew out of Bitzer's (1968) definition of a rhetorical situation, which views rhetorical actions (i.e., genres) as responses to problems in the social world. Embedded in Bitzer's conceptualisation of the rhetorical situation is the notion of *exigence*. Originally, Bitzer described an exigence as an "imperfection marked by urgency" (p. 6). In a similar vein to how a rhetorical situation was viewed as being a discursive response to a problem, an

exigence was viewed as a problem in need of fixing. In fact, Bitzer conceptualised the exigence as the problem or the defect in a rhetorical situation. However, as Miller (1994) discusses, not all situations that require a response need to be problematic.

Miller (1994) adapted the notions of rhetorical situation and exigence, which were later expanded further by Bawarshi (2000) and Paré and Smart (1994), to better suit her more social understanding of genre. Instead of viewing rhetorical discourse as the solution to a problem, Miller (1994) reconceptualises social situations as “social constructs that are the result not of ‘perception’, but of ‘definition’” (p. 24). Here, context and individuals’ understanding of context result from the social construction of a particular situation and a shared interpretation of the kind of action or response the situation demands. The situation is defined by how it is interpreted, based on the context of the current situation and by drawing on knowledge of past similar situations. Social situation refers to the ways in which genre can be enacted “within a particular community in order to regularize writer/reader transactions in ways that allow for the creation of particular knowledge” (Paré & Smart, 1994, p. 122). That is, the social situation is essentially a construct of a community or society, and the way in which a community defines a social situation determines how and why its members will draw upon and enact particular genres. To meet the demand of a defined social situation, typified rhetorical actions, or genres, are enacted.

Not only does Miller (1994) acknowledge social situations as being socially constructed and defined, she also acknowledges how social situations may be recurrent. Miller writes that the recurrences we define are not “material [situations] (a real, objective, factual event) but our construal of a type” (p. 25). That is, our definitions of

recurring social situations are socially constructed, not concrete and material. Through recognising recurring and familiar situations, it is possible to form typified ways to respond to these situations (p. 25). These responsive actions in turn give rise to new social situations demanding a rhetorical response. The relationship between genre and the rhetorical situation is dialectical (Bawarshi, 2000; Paré & Smart, 1994), meaning that in the same way the rhetorical situation creates a rhetorical space for a genre to be created and enacted, the type of response the genre provides also re-creates the context. As Devitt (1993) writes “genre not only responds to but also constructs recurring situations” (p. 577). Put simply, through their use, genres reconstruct the situations that they respond to in the first place.

Miller (1994) also adapts the notion of exigence to better suit her conceptualisation of the social situation. Miller defines exigence as “a form of social knowledge – a mutual construing of objects, events, interests and purposes that not only links them but makes them what they are: an objectified social need” (p. 26). That is, the way in which someone responds to a social situation depends on her or his understanding of what kind of action it calls for. The call to action, as it were, is a situation’s exigence. Of course, as Paré (2014) writes, a genre’s exigence does not necessarily exist prior to the social situation surrounding and being shaped by the genre; instead, it is “an essential part of the [social] situation itself” (p. A87). Thus, an individual’s understanding of how the exigence is connected to a social situation will inform the kind of response they generate to fulfill this social purpose.

Despite the typified and recurrent nature of genre, Miller (1994) points out that genres are not completely stable entities; instead, they “evolve, develop, and decay”

(Freedman & Medway, 1994, p. 8; see also Miller, 1994) as both the social situation and exigence change or disappear. Bazerman (1988) demonstrates this in his investigation into the history of the genre of the research article in physics. He finds that as the goals and operating procedures of the community of physics changed, so too did their writing practices, with the old genre of the article eventually dying out to make way for a genre that better suited the needs of the physics community. This has led to the admission that genres should not be thought of as concrete and stable entities. Rather, they should be conceptualised as "stabilized-for-now or stabilized enough" (Schryer, 1993, p. 203), which allows for the inherent connection between genre and the context in which genres are found, to be foregrounded. Since genres under this conceptualisation are inherently social, it stands to reason that the audience of the text, the person or people to whom the text is directed, plays a very important role in the actions that genre performs.

This view of audience in both the creation and reception of a genre is defined by Bakhtin (1986) as addressivity, which is a genre's "quality of being directed to someone" (p. 95). This notion of addressivity is also discussed by Bitzer (1968), who writes that audience is a component of the rhetorical situation. This conceptualisation, though, considers the audience to be only those who can be influenced by the discourse (p. 8) and neglects to account for the inherent directedness of all types of texts. Thus, in this thesis, I draw on Bakhtin's (1986) notion of addressivity. Bakhtin views utterances, that is "[links] in the chain of speech communication" (p. 84), as being inherently directed toward another. In fact, Bakhtin writes, "the utterance is constructed while taking into account possible responsive reactions, for whose sake, in essence, it is actually created" (p. 94). This essentially means that a genre is always composed *for* someone else,

regardless of whether or not they are meant to be influenced by the text. Texts must be directed toward another individual or individuals.

In addition to this addressive quality, genres are also dialogic, meaning that genres call for a response after they are created (Bakhtin, 1981). As Bakhtin writes, discourse “is directed toward an answer and cannot escape the profound influence of the answering word that it anticipates” (p. 280). Here, Bakhtin demonstrates the directedness of discourse. Utterances are always both answering another prior utterance and awaiting a subsequent response. In the same way, genres are always created in response to an exigence and are responded to by other genres.

The theoretical constructs discussed above, social situation, exigence, and addressivity, underpin the social nature of RGS. RGS views genre, and the situations surrounding genre, as “typified rhetorical actions based in recurrent situations” (Miller, 1994, p. 27). Genres respond to and recreate the social situations surrounding them, respond to and recreate one or several exigence(s), and are addressive in nature. Examining the lab book through this theoretical construction of genre allows me to conceptualise the genre of the lab book as a social device that fulfills particular purposes in the medical physics labs where it is found. Viewing the lab books as instantiations of social action allows me to go beyond simply describing the lab book as a type of text. Investigating the lab book as a form of social action allows me to trace how the lab book is used in the activities of the medical physics lab.

Genre ecologies. Above, I have mainly discussed the concepts used in the theoretical construction of genre. Of course, genres do not exist in isolation; they are connected to each other. These connections between genre lead to them, as Spinuzzi

(2010) writes, rarely being deployed alone. Instead, several genres are usually necessary to accomplish goals or tasks in a given community. This has led to the development of several types of conceptualising and investigating genre combinations, from Devitt's (1991) notion of *genre sets* that refers to the many genres produced by an individual, to Bazerman's (1994) notion of *genre systems* that describes several genres from different authors that act to achieve the goals of a larger system.

One of the first discussions of how genres act together and as a group to facilitate the work of a specific community comes from Devitt (1991). In her discussion of the genres produced by tax accountants, Devitt describes the notion of *genre sets* as "a set of genres interacting to accomplish the work of [a community]" (p. 340). In other words, the genre set is used to examine how genres with distinct, but related, rhetorical purposes produced by an individual member of a specific community accomplish the work of that community. Devitt also writes that genre sets are used to "define and stabilize" (p. 340) the situations and the kinds of work done within particular communities. This particular approach to grouping and tracing genres is focused on the individual and therefore, as Spinuzzi (2004) points out, tends to focus on standardised genres, not on individuals' variations on, or more accurately improvisations on, a genre.

Like Devitt (1991), Bazerman (1994) set out to describe a means of analysing groups of genres. Bazerman, though, extends the notion of genre sets by looking beyond the individual towards systems in which genres are found and interact. He introduces the notion of *genre systems*, which are defined as:

> Interrelated genres that interact with each other in specific settings. Only a limited range of genres may appropriately follow upon another in particular settings,

> because the success conditions of the actions of each require various states of affairs to exist. (p. 82)

That is, genre systems examine how multiple genres produced by multiple authors interact within a particular system in order to get things done in a particular sequence of events. Since Bazerman's original description of genre systems, the notion has become widely adopted to trace how several genres within a particular context respond to and prompt one another (e.g., Russell, 1997; Tardy, 2003). The ubiquity of this approach to tracing genres, though, has led to what Spinuzzi (2004) calls "slippage" (p. 112) in the term. Bazerman's (1994) original conceptualisation of genre systems examined how sequential genres worked together to accomplish particular communicative actions; however, in later studies that adopted the notion, genre systems evolved to become viewed as mediating artefacts rather than just the facilitators of communication (Spinuzzi, 2004, p. 113).

In addition to the above genre groupings, Spinuzzi and Zachry (2000) have proposed the notion of *genre ecologies* as a way of describing how genres enact the work of many individuals to achieve common goals, while acknowledging the dynamism of the genres that community members draw upon. Genre ecologies are defined as an "interrelated group of genres…used to jointly mediate the activities that allow people to accomplish complex objectives " (p. 172). That is, genre ecologies are seen as constellations of genres with dynamic connections to other genres between within and between specific communities. As Spinuzzi (2003) points out, while a specific genre may be used to mediate a specific activity in an AS, it may not be able to respond to the other exigencies that exist in other activity systems and so they must develop "relatively stable

connections or coordinations with other genres" (p. 48). This conceptualisation of genres as focusing on mediation rather than communication is perhaps the defining feature of genre ecologies. Spinuzzi (2004) demonstrates this by writing that "a given genre mediates an activity, but it does not do so alone; *it works in conjunction with the entire ecology of genres available* [emphasis added]" (p. 114). That is, genre ecologies trace the ways in which genres work with each other to mediate activity without emphasising the sequencing of the genres.

The notion of genre ecologies provides a particularly fitting way of conceptualising the relationships between genres in this study because genre ecologies are "constantly importing, hybridizing, and evolving genres" (Spinuzzi, 2004, p. 114), which affects the activities within a particular community. By conceptualising the relationships between genres in a medical physics lab as a genre ecology, it becomes possible to trace connections between prominent genres, such as journal articles, and less visible genres, such as the lab book. In addition, it allows me to examine how genre ecologies adapt to respond to changes or contradictions within the activity of the medical physics labs under investigation.

Writing, Activity, and Genre Research: WAGR

The conceptualisations of activities as mediated by social artefacts and the dynamic, active nature of genres in the RGS tradition complement each other and enable rich investigations into the how genres enable actions in systems. As discussed above, a framework that is especially suited for this study, as it combines the theoretical notion of AT with RGS by focusing specifically on genre as a mediating artefact in activity, is WAGR (Russell, 2009; Spinuzzi, 2010). From this theoretical perspective, documents,

texts, language, and media artefacts are the main mediating tools analysed in an AS. WAGR provides a heuristic that describes the social nature of “textual circulation networks and their contributing role in accomplishing communal work” (Russell, 2009). That is, WAGR allows me to examine the lab book’s role in the network of activity that occurs in the medical physics labs under investigation. In addition, WAGR provides a framework that enables the examination of how the lab book enables the participants within this network to accomplish its communal goals. For instance, WAGR allows me to trace how the medical physics lab book, which I consider to be a cultural artefact, is transformed and adapted in various activity systems.

As discussed above, third generation AT provides a heuristic that can be used to map the outcome of activity. In this study, I am interested in the way lab books are used in medical physics, particularly how the genre of the lab book can be conceptualised as a mediating and cultural artefact. Spinuzzi (2003) writes that in WAGR, genres are viewed as being “crystallized” artefacts (p. 39). By using genre as the main cultural artefact under investigation, WAGR is able to examine how these crystallised artefacts are produced, used, and distributed within a community for a particular goal. That is, by using genre as the main unit of analysis in WAGR, it is possible to trace how texts and documents facilitate activity. While WAGR provides an optimal analytical framework for this study because it conceptualises genre as a mediating artefact, it is necessary to complement it with a theoretical framework that provides a way of conceptualising the collective that is inherent to AT and RGS. For this purpose, I draw on the notion of communities of practice (Wenger, 1998) to supplement WAGR.

Communities of Practice

A theoretical concept that is very closely linked to and indeed, according to Engeström and Miettinen (1999), complementary to AT is that of communities of practice (Lave and Wenger, 1991; Wenger, 1998). A CoP is described by Wenger (1998) as having three distinct components: mutual enterprise, joint engagement, and shared repertoire (p. 73). That is, a CoP can be viewed as a group of like-minded peers who work to achieve a shared goal by using shared discourses, tools, and social artefacts. In this study, I distinguish between two main CoPs: a localised academic CoP that I investigate in my study, in which members of medical physics labs work together toward shared experimental and research goals by using shared tools and shared discourses, and a larger medical physics CoP, in which members of academic medical physics labs, as well as clinical medical physicists working in hospitals, work together toward the advancement of the field, again using shared discourses and tools.

An important concept that Wenger (1998) brings forward in his discussion of CoPs is that of *reificiation*, which refers to "the process of giving form to our experience by producing objects that congeal this experience into 'thingness'" (p. 58). That is, reification is a process that materialises abstract notions, tools, and concepts. Reification can be considered as a way of *pinning down* the abstract tools and artefacts drawn on within a specific community.

Wenger (1998) writes that *participation* within a CoP and the reification of tools and notions within it exist as both "distinct and complementary" (p. 62). He writes that:

> Participation and reification both require and enable each other. On the one hand, it takes our participation to produce, interpret, and use reification; so there is no

> reification without participation. On the other hand, our participation requires interaction and thus generates shortcuts to coordinated meanings that reflect our enterprises and our takes on the world; so there is no participation without reification. (Wenger, 1998, p. 66)

Here, Wenger is describing how in order to produce "congealed" representations of reality (i.e., concretising abstract experiences and concepts), it is necessary to participate in the CoPs that create material tools from abstract notions. To use a concrete example, in order to advance the shared goals within the medical physics CoPs, its members need to draw on material objects and tools, such as the lab book. In tandem with the creation and enactment of these objects and tools, members must communicate the concretised notions with other members to enact their own participation. Basically, in order to create and use the material tools of the community, one must participate within it. At the same time, during this participation it is necessary to communicate and coordinate with other members of the community, which necessitates the reification of the participation itself.

Multimodality

In this section, I briefly outline the definition of mode, multimodality, and medium that I use in this thesis. Subsequently, I introduce the theoretical underpinnings of multimodal interactional analysis (MMI) (Norris, 2004a), which I draw on in my analysis. Before doing so, I should discuss the theoretical understanding of modality in this thesis. Kress and van Leeuwen's (2001) definitions of mode and multimodality have been extremely influential in multimodal research (e.g., Lemke, 1998; O'Halloran, 2009). Their work, though, has its roots in Halliday's functional grammar (Halliday, 1978) which takes somewhat of a different view of discourse than the one I have presented

above. While the terms employed by Kress and van Leeuwen (2001) have their roots in functional grammar, their conceptualisation of notions related to multimodality are taken up by a variety of scholars who do *not* take a Hallidayan view of language and discourse (e.g., Fox & Artemeva, 2012; Norris, 2004b, 2011, 2014). In fact, in her theoretical rendering of MMI, Norris (2004a) draws on Kress and van Leeuwen’s (2001) notions of mode and multimodality, demonstrating the impact their theoretical constructions have had on multimodal research. Thus although, like Norris (2004a), I do not take a functional grammar approach to multimodality, I view the core concepts of mode, multimodality, and medium as being compatible with both the social nature of RGS, as well as the methodological approach offered by MMI, neither of which is rooted in functional grammar.

First, the notion of mode is central to multimodality. In this thesis, I adopt Kress and van Leeuwen’s (2001) definition of mode as a “semiotic [resource which allows] the simultaneous realisation of discourses and types of (inter)action” (p. 21). Modes, according to this definition, are categories of meaning-making (semiotic) tools. These meaning-making tools are used to symbolise or indicate other ideas, things or signs (Graham & Whalen, 2008; Kress, 2003). Basically, a variety of symbolic meaning-making tools, such as drawings, numbers, and writing, are used to represent both material and abstracted objects.

A second concept integral to this thesis is that of multimodality. Here, I view multimodality as “the use of several semiotic modes in the design of a semiotic product or event” (Kress & van Leeuwen, 2001, p. 20). That is, multimodality refers to the way in which several modes combine and work together to create meaning. In this case,

multimodality allows me to examine how a variety of different visual, mathematical, and written modes work in combination with each other, which allows for meaning to be made and communicated.

Since there are several different modes that I am particularly interested in within this study, a specification of how I define these various modes may prove useful. The main textual object of study in this thesis is the medical physics lab book (for a more in-depth discussion of the genre, see Chapter Five), which contains modes that are both visual and symbolic. All of these modes contribute to the overall meaning and social action of the genre in different ways. For my purposes, I differentiate between three different modes: visual modes (sketches and graphs), written modes (text-based notes), and mathematical modes (numerical or alphanumerical mathematical equations).

Finally, in addition to mode and multimodality, medium is a notion that impacts this study. Kress and van Leeuwen (2001) define medium as "the material resources used in the production of semiotic products and events, including both the tools and the materials used" (p. 21). That is, medium refers to the materiality of the meaning-making product, as well as the tools used to create it.

Multimodal interactional analysis (MMI). I draw on Norris's (2004a) MMI to analyse the multimodality present in the lab books (a focused discussion on how I use MMI in my analysis can be found on p. 46). Although MMI was originally developed for use with dynamic interactions and primarily non-textual, embodied modes (i.e., modes that originate with the human body, like gesture, intonation, and movement) (Bhatia, Flowerdew, & Jones, 2008, p. 129), MMI is well suited for this study. The suitability of MMI in this case stems from the conceptualisation of genre as a form of social action. I

view texts as being active and having the ability to "get things done". MMI in turn examines the role of multimodality in interactions and how several modes contribute to the construction of actions and interactions (Norris, 2004a, p. 4). Below, I outline the key theoretical tenet of MMI that I draw on in this study: high-level actions.

In this chapter, I have mentioned how genres can accomplish social actions. Norris (2004a) views actions, such as gestures, language, and intonation, as units of analysis in interactions. Actions may be either lower-level or higher-level. Lower-level actions are the smallest units in an interaction and higher-level actions are made up of multiple lower-level actions that are linked together (p. 11). For instance, in a conversation, the gestures made by those engaged in conversation, the intonation of the conversation, and so on, constitute a chain of lower-level actions, which make up the higher-level action of a meeting. Due to the conceptualisation of genre as social and rhetorical action, I view higher-level actions as the purposes, or the *rhetorical action*, of the genre, and lower-level actions as the multimodal elements that make up the genre and enable its action.

I should point out that in her discussion of MMI, Norris (2004a) distinguishes between the kinds of actions that visual and textual modes can perform and actions performed by embodied modes. Norris views "disembodied modes" (p. 13), or modes like writing that she views as not directly originating from the human body, as frozen action (p. 13). Frozen actions are described as "higher-level actions which were performed by an individual or group of people at an earlier time than the real-time moment of the interaction that is being analysed" (pp. 13-14). That is, Norris views printed or written artefacts as an outcome of a past action. But, as discussed above, I view

genres as being *active* types of texts (Miller, 1994). Thus, unlike Norris (2004a), I view textual and symbolic written and drawn modes not as frozen in particular moment in time, but dynamic and active as they are brought into and respond to human activity.

Before presenting a brief survey of research that has examined knowledge-making in natural and physical sciences, identity construction, and multimodality, I should distinguish between two types of action that I discuss in this study. As mentioned above, when I discuss higher-level actions, I refer to how the modes that combine within the lab book enable the genre to perform specific rhetorical actions. When I examine the way in which the lab book acts as a mediating artefact in an AS, however, I am concerned with how the genre of the lab book is consciously drawn upon by a subject (i.e., a medical physicist) in order to accomplish a particular goal. That is, I distinguish between how the modes in the lab book facilitate the genre’s higher-level rhetorical action in MMI and how the resulting genre is *used* to accomplish a particular outcome when I examine an AS, which is discussed further in Chapter Five.

Chapter Three: The Role of Genre and Multimodality in Constructing Goals, Knowledge, and Identity

This chapter presents previous research that has contributed to the scholarship of writing studies and multimodality in relation to the questions that I presented at the beginning of this thesis, which are:

1. How does the genre of the medical physics lab book facilitate the knowledge-making work of the medical physics community?
2. How does the lab book facilitate discipline member's professional identity construction and maintenance?
3. How does the multimodal nature of the lab book facilitate both the knowledge-making work of the medical physics community and the identity construction and maintenance of its members?

Since there is limited research on the genre of the lab book (see Wickman 2010, 2013 for existing research), I begin by undertaking a brief discussion of the disciplinarity of genre in general; that is, its role in knowledge construction within a discipline and its role in the construction of a discipline itself. Following, the role of genre in the construction and the maintenance of disciplinary identities is explored, which will aid in framing the discussion of the medical physics lab book's role in the identity construction of newer members of the discipline. I end the chapter with a discussion of studies that have examined non-textual elements of natural science genres.

Discipline Specific Writing in the Natural and Physical Sciences

Studies examining distinctive disciplinary genres have led to insights into how the production and distribution of discipline-specific texts serve to construct the body of

knowledge within a discipline (e.g., Bazerman, 1988; Emerson, 2011; Graves, 2005; Myers, 1985a, 1990; Wickman, 2013). These genres are viewed as enacting the preferred ways of knowing and doing of a discipline, which is demonstrated in Bazerman's (1988) large-scale historical exploration of how the accepted procedures of doing experiments and research in physics are reflected in the topics included in physics research articles (e.g., the methods, results, and discussion of results). The texts produced and distributed amongst the physics community become objects of debate, leading to either their acceptance or dismissal within the community.

Graves (2005) also explores how writing constructs disciplinary knowledge in physics. She, for instance, explores the nature of writing in a solid-state physics laboratory. Graves finds that the rhetorical devices employed by the physicists participating in her study are a key part of the development of epistemic claims. In particular, Graves explores how the solid-state physicists she observed in her study drew on rhetorical devices such as analogy, metaphor, and metonymy in order to represent and explain concepts "in a new and different light" (p. 42). She also specifies that the physicists often employed these rhetorical devices to make new and abstract ideas clear to them, in addition to other members of the scientific community. Scientists' awareness of audience and readership in the construction of knowledge-making texts is also examined by Emerson (2011). In her exploration of professional academic scientists' beliefs about and attitudes towards writing, Emerson finds that they "implicitly [perceived] writing to be an intrinsic aspect of the science itself…and perceived the function of writing as being knowledge construction" (p. 367). This finding also alludes to the nature of writing as constructing knowledge within scientific disciplines.

The nature of knowledge construction in physics has also been examined in some detail by Wickman (2010, 2013). In an exploration of the writing in a chemical physics research facility, Wickman (2010) illustrates how the laboratory notebooks kept by chemical physicists serve to integrate the material realities of laboratory work with textual “conceptual” (p. 286) realities. He finds that the lab notebook serves as space that brings together various semiotic modes in order to both provide physicists with a visual representation of “chemical processes that [they] cannot perceive directly” (p. 287). It also serves as a “rhetorical space” (p. 287) in which laboratory work is transformed into a textual resource. Wickman adds that this process enables the laboratory notebook to be subsequently used in knowledge-producing activities.

Investigations into writing in the natural and physical sciences have also shown how science genres are inherently connected to the culture and practices of scientific disciplines. As scholars have demonstrated, the writing practices within disciplines and the written artefacts that are produced within them are deeply embedded in the discipline’s social memory (e.g., Bazerman, 1988; Myers, 1990). That is, the genres that are produced within a specific discipline share a dialectical relationship with their social context. This refers to how genres are not only shaped by and respond to changes in the community using the genres, but also *shape* the communities in which they are found. Bazerman’s (1988) investigation into the evolution of the physics experimental article provides an excellent example of how the genre of the experimental article changed based on evolutions in the physics community. For instance, when experiments stopped being publicly demonstrated, the article became much more descriptive to accommodate for the lack of viewing the actual experiment. By consequence, the community shifted

towards writing as the main source of knowledge, rather than seeing. This particular example that Bazerman presents illustrates the interconnectedness of genre and its community: as one changes, the other must respond to this change.

Genre and the Construction of Identity

A particularly salient notion in this study is that of professional identity formation and development, which has been examined in some detail by writing studies scholars (e.g., Artemeva, 2009; Bazerman, 2002; Paré, 2002). Because genres are created for specific purposes by specific communities, they are steeped in the communities' practices and ideologies. Consequently, when genres are produced by individual community members, they not only shape the realities of the individual, but also the individual her- or himself (Bawarshi, 2000, p. 353). That is, by enacting genre, an individual also enacts the ideologies and beliefs embedded within the genre itself, and begins to develop the professional identity, which being a part of a specific CoP entails. Artemeva (2009), for instance, examines how novice engineers gradually, and from encounters in several professional contexts, begin to develop "knowledgeably skilled [identities]" (p. 162) in part through learning to produce professional genres.

Schryer and Spoel (2005) also illustrate genre's role in professional identity formation in their study examining the negotiation of healthcare workers' professional identities. They find that it is through interacting with institutional texts and discourses, such as case presentations (a presentation where advanced students give their analysis of a patient's case to faculty members [p. 260]) and medical policy documents that the workers' professional identities are shaped through "regulated as well as regularized genre activity" (p. 267). That is, the professional identities of healthcare workers are

shaped by their learning and their use of rule-governed (regulated), as well as flexible and situational (regularised) genres.

Of course, there may also be resistance towards adopting the kind of genred identity necessitated by the norms and regulations of a CoP. Paré (2002), for instance, examines how Inuit women resist the institutional identity they are expected to ascribe to when composing social work reports. He finds that there is a disconnect between the expectations of the predominately "southern, urban" (p. 62) members of the social work system and the cultural identity of the Inuit women. This struggle between institutional and cultural identity hindered the women from participating in institutional genres, which themselves are "collective and conservative forces operating to make sense 'common' and to locate individuals in identities . . . that maintain ideologies and allow them to pass as 'sense'" (p. 68). The inherent connection between identity and genre that Paré explores again illustrates the power genres have within CoPs. The ability to produce genres of a CoP appropriately is closely connected with the development, or at the very least the recognition, of the specific identities embedded within the genres.

Writing and Visualising the Natural and Physical Sciences

The representation of knowledge in several modes, such as mathematical notations (Barany & MacKenzie, 2014), charts (Wickman, 2013), and illustrations (Vertesi, 2014) have been found to play a very important role in the construction of scientific claims. As I discussed above (see Chapter One), an increasing number of these non-textual representations are changing in response to evolutions in technology used in laboratory research. This heightened sense of importance associated with the study of

visual representation in science genres is complemented by rising interest in the role of multimodality in knowledge construction.

While earlier studies have focused mainly on text, recent investigations into knowledge-making practices in science have expanded to include visual and textual representations (e.g., Lemke, 1998; Wickman, 2015). These investigations have demonstrated that in order to fully understand the role of genre in the knowledge-making work that happens in natural science contexts, it is necessary to examine the non-textual elements of the myriad of genres that are produced and consumed in natural science disciplines. Wickman (2015), for instance, examines how a doctoral student in theoretical physics constructs and reports on computation simulations, the results of which are often represented visually, in a doctoral dissertation. He finds that the semiotic representations that the student generates are not simply representations of material objects, but are “epistemic practices” (p. 61) that allow for the digital creation of non-physical objects.

In a similar vein to Wickman (2015), de Rijcke and Beaulieu (2014) examine digital brain scans and investigate how networked technologies that are used to produce the scan and how the scans become authoritative representations in drawing conclusions about the brain. In particular, they examine what they call “brain atlases” (p. 131), collections of brain scans that are networked through databases and other interfaces which function as authoritative images that “reveal preferred epistemic and ontological stances of a scientific field” (p. 133). They find that the visual brain atlases, like physics journal articles, both reflect and reproduce ways of knowing and doing in medicine and medical research (p. 141).

In addition to simulations and scans, images also serve an important purpose in scientific genres. Vertesi (2014), for instance, examines the role of illustrations in a presentation proposing further research in a specific region of Mars as part of the Mars Exploration Rover mission. She finds that the success of this proposal relied heavily on the digital illustrations that presented a coloured version of the soil in this particular area. Vertesi writes that by creating these illustrations, the research team produced new insights into the knowledge bank of the project (p. 31). Without the illustrations produced in this project, the proposal to further investigate soil composition may not have been successful.

Past research examining not only knowledge construction within science disciplines, as well as investigations into identity and multimodality, provide background for the current study to build from. In the following chapter, I outline the methods used in order to develop and analyse the discipline of medical physics specifically.

Chapter Four: Methods

In this chapter, I present the methods used in this qualitative study. Due to the involvement of human participants in this study, the Carleton University Research Ethics Board (CUREB) was made aware of and approved this study (see Appendix A). Furthermore, to protect the confidentiality of the physicists, all participants are provided with pseudonyms and all identifying information has been redacted from all data.

The study has an emergent research design, which has enabled data analysis to be flexible and change in response to new and unforeseen details that have emerged during the research process (Dörnyei, 2007, p. 37). The data collected from the participants are presented along with the methods of analysis used.

Research Site and Participants

Research site. This study was carried out at a mid-sized Canadian Research University, henceforth known as CRU, specifically, in the medical physics unit. Currently, this unit specialises in two different fields within medical physics: imaging and radiation therapy. In this particular department, imaging research ranges from improving tissue contrast (i.e., contrast between bone, fat tissue, and muscle tissue) in x-rays, to the reconstruction of positron emission tomography (PET)[2] and computerised tomography (CT)[3] scans of lung cancer and cardiac patients for the purpose of improving the image quality, to using imaging techniques for the purpose of guiding radiation therapy (S_INT1_July21). Radiation therapy physics is the second main research area in

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[2] PET scanning is an imaging technique in nuclear medicine where a patient is injected with a small dose of radioactive liquid that locates tumour growth or weak cardiac muscles.

[3] CT scanning is an imaging technique where multiple x-rays are taken from different orientations to create a three-dimensional rendering of a patient.

the program. In this area of medical physics, the research conducted in the department ranges from planning radiation therapy by using Monte Carlo[4] simulations to model radiation treatments, to the delivery of radiation treatments and the development of novel radiation therapy, to monitoring radiation therapy and dosimetry, or the calculation of the dose of radiation in a patient undergoing therapy (P_INT1_August19). The medical physics department is also a part of the local medical physics institute, which consists of a network of medical physicists who work in a variety of contexts such as CRU, local hospitals, government research centres, and cardiovascular health centres. While there are a number of contexts in which the faculty of CRU's medical physics unit works, I focus mainly on faculty members' work as academic medical physicists.

Participants. There are, at the time of this study, six faculty members in CRU's medical physics program, ranging from two new assistant professors to two experienced full professors. Two of the faculty members, both working in radiation therapy physics, are Canada Research Chairs. In this study, four faculty members and one doctoral candidate acted as participants. In the following paragraphs, I first present the sampling strategy that I used before introducing each participant and briefly describing their research and their position in the field.

Participants were first recruited by using a convenience sampling strategy, which according to Dörneyi (2007), is the selection of participants based on individuals who are available (p. 129). In this case, I first searched CRU's physics website to identify all faculty members in the medical physics field and subsequently contacted five of the six

[4] Monte Carlo techniques are based off of algorithms that calculate, for instance, the direction of photon beams, the scatter of beams, and the number of beams to reach a simulated patient (Rogers, 2006).

medical physicists in the department to elicit their willingness to participate in this study; the sixth medical physicist was on leave during the recruitment stage. Out of these five, four agreed to participate in the study. The physicist who declined to participate did so because of being too busy with other commitments. In addition to the four academic physicists, my sample includes a doctoral student who volunteered to be part of the study after being made aware of it by his supervisor. Participants are introduced below.

Professor Poole is a senior member of the medical physics community, having been a part of the field for over thirty years. He is a full professor at CRU and is one of the Canada Research Chairs in the department. His research is mainly in the field of radiation therapy, specifically, in planning radiation therapy treatments using Monte Carlo simulations. In fact, Professor Poole was involved in the creation of one of these Monte Carlo simulations, which models particle accelerators used in radiation therapy. Professor Poole not only plans radiation therapies, he also does research in the field of dosimetry. Methods of dosimetry are used to “[quantify] the amount of radiation absorbed in volumes of tissue” (Köster et al., 2013, p. 566) to determine the correct dose of radiation for a patient undergoing radiation therapy.

Professor Poole’s involvement within the medical physics community extends beyond his research contributions. He was the associate editor of the main journal in the field and at the time of this study is still a member of the journal’s board of editors. He is also an active referee of scholarly articles submitted to this and other journals in the field. Because of his long involvement with the journal, Professor Poole has been invited to speak at international conferences about writing for and reviewing for the journal. He also gives a talk on this topic at the beginning of each new academic year to incoming

graduate students in the medical physics unit. Graduate students in the medical physics department have also acknowledged Professor Poole’s mentoring ability. In 2011, Professor Poole was one of the recipients of one of CRU’s graduate mentoring awards, a student nominated award that recognises outstanding mentoring by a faculty member.

Another expert member of the field at CRU is Professor Burke, who is a full professor and who has worked in medical physics since the 1980’s. Professor Burke’s area of research is imaging. More specifically, his work involves developing scatter x-ray imaging techniques that employ physics from x-ray crystallography, which are used in developing lab instruments to analyse specimens of minerals and crystallised proteins (B_INT1_July9). Professor Burke has also advised and mentored a number of graduate students in the physics department in his previous role of graduate advisor.

Another participant in this study is Dr. Lee, an associate professor in medical physics. Dr. Lee’s main area of research is related to both radiation therapy and imaging. One of the main projects he is working on with his students is developing radioactive tracking devices that can be used to track the movement of cancerous tumours during radiation therapy, as well as how these tracking devices may be used to guide surgeries of the heart and brain.

Dr. Britney is an assistant professor who has studied medical physics for fourteen years and has recently joined the faculty at CRU. Like Professor Poole’s, her main area of research is using radiation therapy to treat cancer. Her research is mainly concentrated on computer simulations of cancer treatments, as well as the exploration of how medical imaging techniques might be used to more effectively target cancer cells in the body. Dr. Britney is also involved in “outreach” programs run by the CRU physics department.

Specifically, she has presented her research to members of the general public at mini-lectures hosted by the Faculty of Science at CRU.

Finally, Dr. Lee’s doctoral student, Sean, is the most novice medical physicist in this study. Sean is, at the time of this study, in his last year of his doctoral studies. Prior to becoming a PhD candidate, he completed his Master’s degree under Dr. Lee’s supervision. Sean has been involved in Dr. Lee’s research on positron emission tomography tracking (PeTrack), where radioactive trackers are used to increase the accuracy of the delivery of radiation to a cancerous tumour. Recently, Sean has started working with the local cardiovascular institute to apply PeTrack to cardiovascular patients.

Due to the limited scope of this thesis, a maximum variation sampling strategy (Dörnyei, 2007, p. 128) was used to select three of the physicists to be discussed in detail: Professor Poole, Dr. Britney, and Sean. The maximum variation sampling strategy allowed me to focus in more detail on cases with “different forms of experience” (p. 128) in order to locate variations and patterns amongst the sample group. In this case, the parameter that I used to select participants was the number of years of experience working in the field. Using this parameter to choose the cases allows me to examine participants with a range of experience, from a globally recognised expert to a novice professor to a doctoral student. This range of experience is useful in comparing and contrasting how the participants use their lab book within their respective labs, especially in relation to the lab book’s role in identity construction. These three researchers also represent the range of research interests within the medical physics department, thus

showcasing how each sub-field is aware of how its work is connected to the work of other researchers in a different sub-field.

Data Collected, Units of Analysis, and Methods of Analysis

Data collected. In this section I outline the data that were collected for this study, the units of analysis used in the study, and the method of analysing the data.

Data collected include semi-structured interviews, samples of texts written by the participants (e.g., lab books, conference presentations, and journal articles with comments from editors and reviewers), observations, and field notes (Table 1). Due to some of the participants’ research occurring in hospital settings, I was only able to observe two of the participants, Professors Poole and Burke, in a professional setting. In these two cases, my observations were the first type of data collected from participants. I recorded details of both observations in field notes, which were labelled with times, dates, and locations of the observation (e.g., B_OBS_July4HP_2:30). These notes, in addition to being used in my analysis, helped to inform subsequent interviews with Professors Poole and Burke. For example, field notes from observing Professor Burke working with one of his students informed questions related to student mentoring and field notes from observing Professor Poole run simulations informed questions about research processes.

After initial observation when possible, I conducted individual, semi-structured interviews with all participants. I digitally recorded and transcribed all interviews. These transcriptions were labelled with the time, date, and location of each interview (e.g., B_INT1_July9HP_11:00). I also collected field notes during interviews, which were used

to supplement my analysis and record examples of images and references to journals that participants used to help explain their answers to my interview questions.

Following interviews, I collected textual samples from all participants, with the exception of Dr. Lee. This is because Dr. Lee views his research as being inseparable from his students’ research (L_INT1_July25), and for this reason I focused on analysing Sean’s texts since he is one of Dr. Lee’s doctoral students. Participants were the sole authors of some texts, specifically the lab books and conference presentations, whereas journal articles were written in collaboration with colleagues, students, or mentors. The only textual samples I collected that my participants did not produce were the comments made by referees and editors on journal manuscripts. In line with the emergent design of this study, after analysing interview transcripts and field notes from observations, I noticed that lab books serve a key function in the medical physics labs under investigation. The lab book serves as a springboard for other knowledge-making texts, such as conference presentations, journal articles, and dissertations (discussed further in Chapter Six). For this reason, I chose to focus my textual analysis on lab books.

In this study, there are two types of lab books: a more traditional paper lab book and an electronic lab book, which consists of Excel spreadsheets, graphs, tables, and typed notes. Due to the difference of medium (i.e., whether the book is paper or created on the computer) in the two types of books, however, the selection of entries to analyse differed slightly. For the traditional lab books, I chose three entries, most of which are approximately one to four pages in length, to analyse in detail: one from the beginning of the book, one from the middle, and one from the end. I specifically included entries that consisted of a mix of textual and non-textual modes, for instance, sketches of a PET

scanner or graphs stapled into the book. Since the electronic lab book is not organised in the same way as the traditional paper lab book, I chose to select three different data files to analyse: one graph, a summary of results, and a summary table of various simulation results.

Table 1

Total Data and Data Types Collected from Participants

Data Type	Collected From	Total Data
Digitally Recorded Interviews	All Participants	320 minutes and 33 seconds
Interview Transcripts	All Participants	~ 41,007 words
Paper Lab Books	Britney, Burke, Sean	~ 600 pages
Electronic Lab Books	Poole	46 files
Conference Presentations	Britney, Poole, Sean	201 PowerPoint slides
Journal Article with Referee and Editor Comments	Britney, Burke, Poole, Sean	329 pages
Observation	Burke, Poole	80 minutes
Field Notes	Britney, Burke*, Lee, Poole*, Sean	13 handwritten pages

Note. Asterisks (*) indicate instances where field notes were collected during observation and interviews.

Unit of analysis. One of the most important decisions preceding the analysis was the identification of the unit of analysis for interview analysis and the analysis of the lab books. In this study, I chose to separate my data into meaningful chunks. These chunks are segments of text that are relevant to the research questions being asked and "whose size and content lend themselves to fruitful analytic reflection [that helps answer the research questions]" (Wertz, 2011, p. 131). Before I was able to determine the smallest possible meaningful chunks, I began with a larger unit: in interview data, this initial unit was the answer to an interview question, and in the lab books it was a single lab book entry. Due to the varied nature of the data in this study, the way in which I went about refining my initial unit of analysis into its most reduced form changed depending on the nature of the data, which I explain below.

My initial unit of analysis for interview data was the answer to a question. That is, a participant's answer to an interview question was initially conceptualised and coded as one unit; however, upon further investigation I realised that my initial unit was too large. It disabled me from distinguishing between the initial answer and the subsequent digressions that were meaningful to my research questions. For instance, during my interview with Professor Poole, I asked a question about the possibility of graphs and figures becoming standardised, which he replied to with a 450-word response. In this response, Professor Poole not only discusses the possibility of graphs and figures becoming formally standardised, he also talks about why this is unlikely by explaining the kinds of feedback referees give and technical imaging standards such as Digital Imaging and Communication in Medicine (DICOM)[5], which are already enforced. While

[5] A standard for storing and sharing images captured by MRI, PET, and CT scanners.

related to my original questions, I consider information about refereeing and existing standards to be distinct chunks of information that communicate complete meanings. Thus, meaningful units used to code interviews are conceptualised as a section of text that communicates one complete and coherent chunk of new or different information (see Appendix C).

Like in the interview data, lab books were separated into meaningful chunks as units of analysis. Again, I started with a large unit of analysis, the entire entry. I considered each entry in a lab book to be a response to a specific purpose of the participant’s work. For instance, Sean’s earliest lab book entry is four pages long and records an experiment that tracks the motion of irradiated and non-irradiated plates using a PET scanner (see Figure 4.2). Sean tracked several different configurations of plates and each configuration was sketched in the lab book and was accompanied by the filenames that recorded a specific configuration, the distance of the plates from the centre of the scanner, and the duration of the scan. The sketches in the lab books tend to organise information, in this case the filenames and the spatial and temporal organisation of the plate configuration, into a specific chunk of information. While some full entries may constitute a single meaningful unit of analysis, in other cases a single entry may have several different functions, and thus need to be separated into separate chunks. In Dr. Britney’s lab book, for instance, an entry may start with a record of notes on a conference call with her research collaborators, continue with equations and sketches of geometries to test for a research project, and end with a list of simulations to run (see Figure 5. 15). In this case, the record of each task would constitute one unit of analysis. For Professor Poole’s electronic lab book, I originally conceptualised individual files as

separate meaningful chunks of information; however, some of the files need to be read together for the information to make sense. Figure 5.16 shows a graph and a data file from Professor Poole’s electronic lab book. In this case, it is necessary to read the two files together to make meaning and constitute a single meaningful chunk of data.

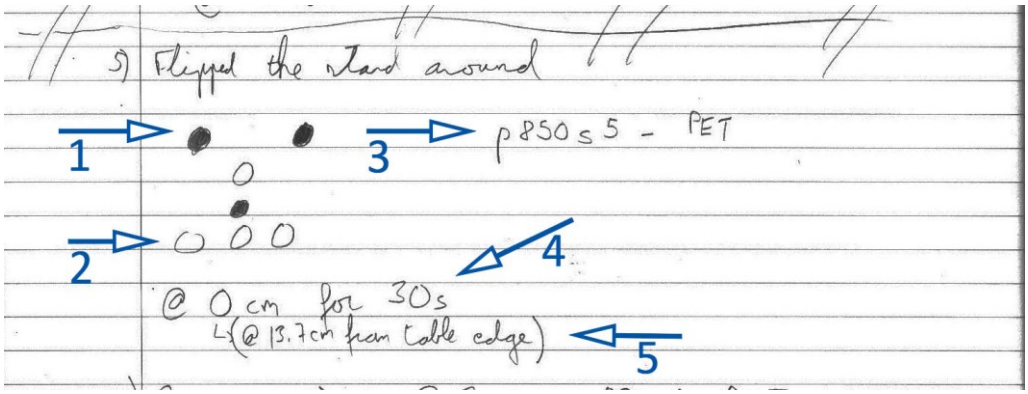

Figure 4.2. A sample meaningful unit from the lab book. This figure illustrates a meaningful unit from Sean’s lab book showing a sketch of plate configuration from PeTrack experiment. Dark circles indicate irradiated plates (1), blank circles indicate non-irradiated plates (2), and filename (3), duration of the scan (4), and distance from the scanner (5) are recorded.

Methods of analysis. Within the emergent research design of this study, the actual analysis of data was carried out using thematic, “template”, and multimodal interactional analysis techniques (MMI). These techniques, which are explained in greater detail further in this study, allow the researcher to take an interpretive approach to data analysis (Crabtree & Miller, 1999). That is, thematic and “template” analytical approaches both acknowledge that the social world being investigated as being co-constructed by the researcher and her participants. The analytical approaches this study draws on are Smith’s (2006) and Charmaz’s (2006) interpretive and emergent

conceptualisations of qualitative research. It begins with a thematic analysis of the data and subsequently refines themes until the data reach saturation.

Thematic analysis. Smith (2006) advocates starting from within the data and "recognising the authority of the [informant] to inform [the researcher]" (p. 138). That is, initial data analysis should not begin by immediately superimposing theory on the experiences and beliefs of participants, but should instead try to recognise relationships within the data that participants allude to.[6] Indeed, in this particular study, I am an outsider to the community of medical physics. While the status of "outsider" has several benefits, such as the ability to remain relatively free of any analytical biases during the collection of data, it also comes with the pitfall of knowing very little about the community under investigation. Thus, an analytical method that recognises the expertise of informants is, in this case, both necessary and helpful to the unbiased collection of data.

Along with recognising the expertise of informants, I also included member checks (Bazeley, 2013) as a triangulation technique. Member checks, which I performed after a thorough analysis of my data, offered me the opportunity to validate or correct my interpretation of the data with the study participants (p. 89). In this case, member checks were especially beneficial for checking my interpretation of lab book entries.

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[6] Here, I would like to acknowledge that while WAGR, in particular AT, *does* superimpose a theoretical perspective on data, in particular the use of the AS as a theoretical unit of analysis, this theoretical framework was adopted subsequent to the collection and preliminary analysis of data. That is, after the initial collection and analysis of data, I discovered that WAGR provided a framework that complemented both my data and my initial analysis of the data. So while WAGR is introduced earlier in this thesis, the construct was integrated into the study after preliminary "bottom-up" analysis.

Like Smith (2006), Charmaz (2006) eschews superimposing theoretical constructs on the experiences of participants before the process of coding and refining data. Charmaz developed a style of constructivist grounded analysis that shifts away from traditional positivistic grounded analysis (Glaser & Strauss, 1967). Positivistic grounded analysis tended to favour theory as generalising and universal explanations of phenomena (Charmaz, 2006, p. 126), to a more interpretive and fluid conceptualisation of the social world. In this study, I adopt Charmaz's constructivist approach. Instead of reducing the world into select conceptual “boxes”, constructivist grounded analysis, in the same line as thematic analysis, views the world as being made up of the “shared experiences” (p. 130) of and the relationship between researchers and participants. This social world is also shaped by the interpretation of other forms of data, such as text and observation. Since constructivist standpoints view data and data analysis as being co-created by the researcher and participant, this version of grounded analysis is interpretive in nature, recognising that researchers are members of the social world that they are engaged in studying. This recognition of researchers being situated in the context which they are discovering also assumes that any theory that is derived from data is an interpretive, not exact, rendering of the world (p. 10). Acknowledging, as Smith (2006) does, the expertise of members of the community under investigation allows me to render an informed interpretation of the world of medical physics, or at least, the particular community of CRU within it.

To this end, thematic analysis aligns with this way of thinking about data analysis because it allows the researcher to begin the analysis by finding recurring themes from the data and grouping them into more abstract categories (Fereday & Muir-Cochrane,

2006). Using the data as a starting point toward the development of theory is important because, as Smith (2006) writes, the researcher should always start from embodied experiences of participants, where by embodied refers to the experiences and actions of an individual from within their own bodies (p. 126). That is, in order to truly obtain an accurate understanding of the writing, knowledge-making, and identity construction of academic medical physicists, it is important to derive meaning out of the texts and explanations of the physicists themselves. Finding meaningful categories from coded interview and textual data before abstracting said categories into theoretical concepts (Saldaña, 2009, p. 12) ensures not only that meaning will be made from the participants' experiences, but also that the researcher and participants are co-constructing the meaning of the data.

"Template" analysis. In combination with deductive thematic analysis, a more inductive and *a priori* template analysis was used (Crabtree & Miller, 1999). The template organises the emergent themes from the earlier thematic analysis in order to show the hierarchical relationships between the categories. While thematic analysis can appear rigid and constraining, the templates that are created from thematic analysis are flexible and can change to accommodate unforeseen connections within the data (King, 2004). I developed a template by drawing on the emergent themes of three of the five interviews, specifically interviews with Professor Poole, Dr. Britney, and Sean.

MMI analysis: Modal intensity, modal complexity, and modal density. To investigate the multimodal nature of the lab books, I draw on Norris's (2004a) MMI, whose theoretical underpinnings have already been discussed (p. 26). Specifically, my analysis examines the modal intensity and modal complexity of the lab books, which

combined constitute modal density. Modal intensity refers to the weight or importance a specific mode has in a multimodal interaction (Norris, 2004a, p. 79). That is, the intensity of a mode is determined by how it contributes to the overall awareness of the action being performed. For instance, in an exploration of multimodal advertisements White (2010) explains how posters that employ few communicative modes are intense because each mode has an impact on how the reader responds to the poster (p. 375).

In multimodal texts, individual modes can assume high, medium, or low modal intensity. When a mode carries high intensity, it takes on primacy in the action (Norris, 2004a, p. 83). Norris views modes as carrying high intensity when they structure other modes and when an action would not be possible without a mode being intensified (p. 83). For instance, in a phone conversation, the only mode in use is spoken language, making it very intense. In fact, the mode of spoken conversation in this example is so intense, were it discontinued the action of speaking on the phone would be impossible. When a mode takes on medium intensity, it does not structure other modes, although it may change the action being performed. When a mode takes on low intensity, it has the opposite result of high intensity modes: other modes are not structured by low intensity modes and actions remain possible when modes are not intensified.

In addition to modal intensity, modal complexity also plays a role in the ability of genre to construct actions. Modal complexity is the "interplay of many different communicative roles" (Norris, 2004a, p. 87). Modal complexity is achieved when several different modes are closely connected and work together to make meaning. Unlike modal intensity, if a mode is changed or removed in a modally complex action, the action will not be drastically altered. For instance, a modally complex lab book entry might have

several different modes such as sketches of a PET scanner, mathematical equations, and jotted notes that interconnect to perform a higher level action of creating a simulated PET scanner.

When modal intensity and modal complexity combine to achieve a higher-level action, they create what Norris (2004a) calls modal density. Modal density refers to "the modal intensity and/or the modal complexity through which a higher-level action is constructed" (Norris, 2004a, p. 79). That is, the importance (intensity) of a mode and the interconnectedness (complexity) of several modes reveal the awareness or attention that a participant places on a higher-level action (p. 150). The higher the modal density, the more awareness participants have of higher-level, rhetorical actions. If modal density is low, however, an individual will background their awareness of higher-level actions, but will still remain somewhat aware of these higher-level actions (p. 150). In other words, high modal density foregrounds, reacts to, or acts upon a specific signal (Norris, 2004a, p. 104).

Since modal density is used to examine how high-level actions are performed through multimodal means, I combine multimodal analysis with rhetorical genre analysis. As I previously discussed, rhetorical genre studies views text as forms of social action; therefore, I examine the rhetorical action produced by the lab book entries. To do so, I drew on Devitt, Reiff, and Bawarshi's (2003) genre analysis guidelines, which guides the rhetorical analysis of the genre's purpose, audience, social situation, and medium. I was particularly concerned with analysing the rhetorical purposes and audience of the lab book entries because, in this case, the purpose and audience of the lab book are important in determining how the lab books are taken up by members of the physics community

and how they are *hooked into* the larger physics community (e.g., the lab book's role in the development of conference presentations, journal articles).

Reliability among coders. In order to ensure that my template codes were reliable, I conducted an inter-coder reliability test. Five inter-coders[7] were asked to use descriptive codes on a 1375 word segment of Professor Poole's interview, which I felt contained a number of important codes for this study (see Appendix C). Since not all of the coders were familiar with my study, I provided them with my research questions and the context of the interview. The interview was divided into analytical units for the coders. I calculated the Cronbach Alpha based on the first fifteen codes to determine reliability. This particular test measures the internal consistency reliability, that is, it measures how homogenous the data in a particular group are (Dörnyei, 2007, p. 206). I used the Cronbach Alpha to make sure that my codes were homogenous with the codes of other coders. Since the Cronbach Alpha is most commonly used with a single coder, I eliminated the two coders who seemed to have limited background knowledge of either coding or the theoretical background used in this study. The Cronbach Alpha of the remaining three coders returned a result of α=0.85. This number indicates a reliable coding score, as the Cronbach alpha normally aims for a reliability coefficient of 0.70 or above (p. 207).

In the following chapter, I present the analysis and the findings that developed out of the data described in this chapter.

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[7] Many thanks to Dr. Janna Fox for her help navigating the statistical tests and to the students in ALDS 6102 for generously volunteering their time and acting as coders for this project.

Chapter Five: Findings and Analysis

The medical physicists in CRU's medical physics unit draw on and produce a number of genres as a part of their knowledge-making work. A great deal of knowledge construction, as well as the construction of the discipline, occurs in the writing of peer-reviewed journal articles, which are accepted as contributions to the global medical physics community. This very visible knowledge-making would, however, not be possible without the production of other less visible genres. The lab book acts as an important locus of knowledge making work within the discipline. In this section, I present an analysis of the lab book as a genre and its role within the medical physics genre ecology.

Before presenting the analysis and findings, I should acknowledge that I used interview data in order to guide the multimodal analysis of the lab book. As I stated in Chapter Four, I am not an "insider" to the medical physics community and do not possess the necessary background to accurately interpret lab book entries without the guidance of their authors. Therefore, in this section, I draw on interview data for the rhetorical analysis of the lab book. My subsequent multimodal analysis is guided by the findings of the rhetorical analysis of the lab book. In addition, the findings from the multimodal analysis were verified during member check interviews to ensure that I was drawing accurate conclusions from the multimodal data.

Rhetorical Analysis of Lab Books: Audience, Medium, and Purpose

Data analysis began with coding the semi-structured interviews that I conducted with my participants. The interviews and the initial interview coding were both informed by my original research questions; however, because my interviews were semi-structured

and my study has an emergent design, some of the data directed me to questions that I had not anticipated. The interviews yielded emergent themes that recurred throughout all of my interviews with the participants (Saldaña, 2009). The most common of these themes included concepts related to teaching and mentoring, identity, and knowledge construction. In addition to these concepts, coding also yielded emergent information about the lab book. When designing this study, I expected that in order to examine the knowledge-making practices of medical physics I would need to examine journal articles; however, during the coding process it became evident that the lab book functioned as an integral part of the knowledge-making practices in medical physics. Figure 5.3 presents a portion of my coding that encompasses the main trends from interview coding.

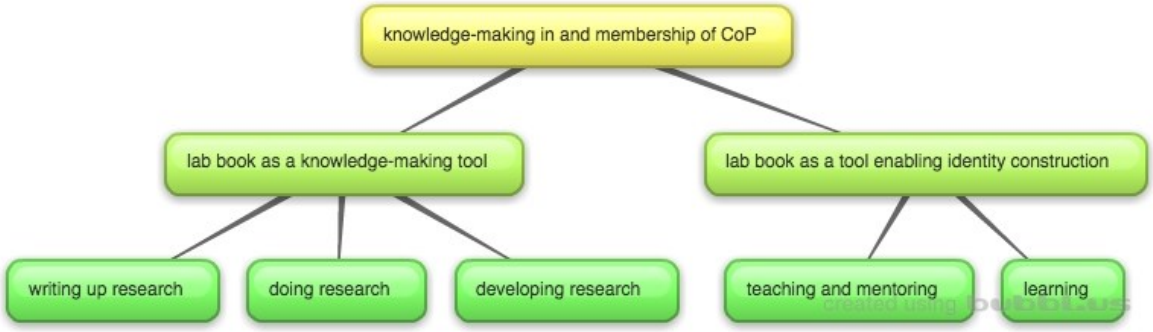


Figure 5.3. Knowledge-making and CoP coding tree. This figure illustrates the main themes interview coding (knowledge-making genres and community of practice) and the lower-level categories that progressed into the main themes.

The coding tree in Figure 5.3 shows how lower-level categories (i.e., doing research and developing research) are subsumed by categories that describe how the lab book is used by participants in this study. The bottom rows of the tree subsequently feed into higher-level, more theoretical themes, which describe the lab book’s role in

knowledge and identity construction within the medical physics CoP. The coding tree generated from the interview coding revealed the important role that the lab book adopts in several important aspects of laboratory work. First, the lab book is closely tied to both developing and doing research in medical physics. Second, the lab book plays an important role in the writing up of these results into other genres, including conference presentations and journal articles. Third, the lab book is closely connected to the teaching and mentoring practices within the medical physics labs that I investigated.

While the rhetorical purposes of a genre are, at least according to RGS genre analysis, the most important features in determining what a genre is and what it does (e.g. Devitt, Reiff, & Bawarshi, 2003), I begin my analysis by examining the audience and medium of the lab book. Analysing the audience and the medium prior to the rhetorical purposes of the lab book is, in this case, necessary because it allows me to explain two important parts of the rhetorical situation of the lab book: who uses the lab book and what the lab book looks like.

Audience. Awareness of the intended audience of the lab book was a recurring code in interview data (see Figure 5.4). One reason for the recurrence of this code emerged from the participants’ discussing the importance of being able to easily read and understand lab book entries.

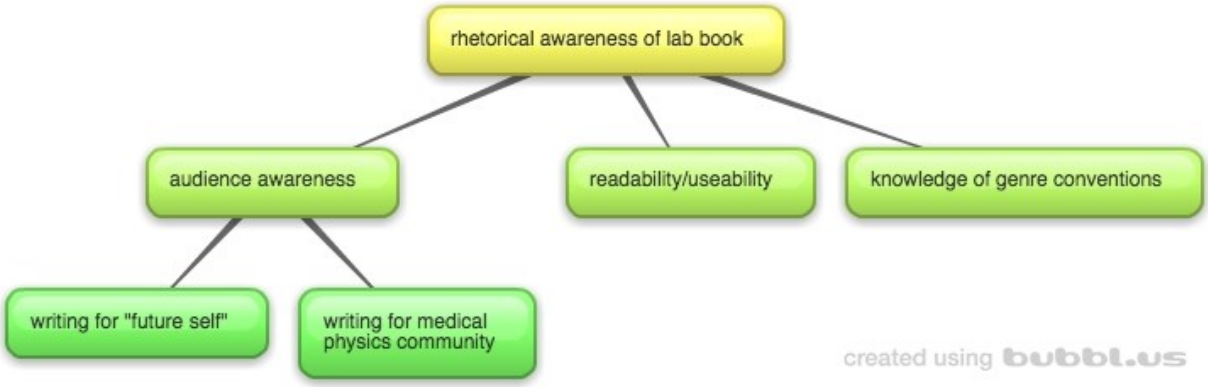


Figure 5.4. Rhetorical awareness coding tree. This figure shows the rhetorical awareness of the lab book, including audience awareness; lower-level categories occupy the bottom level, more abstract themes the top.

In medical physics, the lab book is a fairly ubiquitous text; that is, the lab book is not a document kept only by professional academics in the field. As Dr. Britney and Professor Burke explained to me, they encourage all students, whether they are graduates or undergraduates, to keep and use a lab book when they are doing research. Professor Burke told me about the importance of lab book during our interview (B_INT1_July9). Prior to this interview, I had observed a meeting between Professor Burke and his summer student. During the meeting, Professor Burke walked the student through equations that he thought might help rectify an issue in the student's programming code. In our interview, I asked Professor Burke about the equations he was working on with his student. He explained that he hoped the student was keeping track of the equations in his own lab book and understanding the reasoning behind why the equation is important (B_INT1_July9). Similarly, Dr. Britney explained that she wants all of her graduate students to keep lab books because it helps them to become better researchers. She views the lab book as a means of "training grad students" to follow research procedures and

produce reliable results (Br_MC_February2). In both of these examples, the lab book serves as a means of training students to keep records of not only the results of their experimental work, but also of the process and procedures students took to find their results.

The primary audience of the lab book, as perceived by the medical physicists who are writing it, is the writer her- or himself. For instance, when I asked Professor Burke about the kinds of audiences he writes for he explained that, in the case of the lab books, he expects to be the sole reader (B_INT1_July9). Like Professor Burke, the other four participants all believed themselves to be the sole audience of the lab book and as such kept records so that they would be able to understand and keep track of their work in the future. Again, Professor Burke explained to me that although the lab book is written mainly for the researcher creating the lab book entry, “you write it down ideally for someone else . . . and it works in the sense that if you come back and read your own logbook a month later, it’s almost like you’re someone else” (B_INT1_July9). Here, Professor Burke describes how the lab book should ideally be written for a future self, meaning that the person returning to a lab book entry a week or a month later is in some ways, as Professor Burke says, a different person that will likely struggle to understand the contents of a lab book entry (B_INT1_July9). The awareness of the imagined audience of the lab book that Professor Burke articulates echoes the notion of addressivity embedded in genres (Bakhtin, 1986). The lab book is produced so that it can be addressed to someone else, most likely the writer’s future self. His awareness of the addressive nature, as well as the imagined future audience, of the lab book allows Professor Burke to respond to the contents of a lab book entry and act on those contents.

By writing the lab book for his imagined future self, the lab book facilitates Professor Burke's own ability to easily remember and draw on past research and experiments.

While the perceived primary audience of the lab book is the lab book's creator, a less common audience (or at least an audience that the participants in this study do not think about as often) is other medical physicists working in the same lab as the book's author and/or in other labs or in hospitals. For instance, Professor Burke has several lab book entries which he wrote specifically for both himself *and his student collaborator* during a collaborative project (B_INT1_July9). Professor Poole is also aware of how the reader of the lab book may be another physicist; for example, in a recently published article, Professor Poole challenges a claim made by one of the top medical physicists in the field of radiation therapy (P_MC_December18). He explained to me that it was important to keep a careful record of all of the experimental work in his electronic lab book in case his own claim was challenged by another member of the medical physics community (P_MC_December18). Professor Poole, I would argue, was aware of two potential imagined audiences when creating the entries in his electronic lab book. The first is the imagined audience of the medical physics community. Since the journal letter that Professor Poole eventually published questioned the necessity of the original article, he was aware that he needed to be able to "dig up the evidence and have firm information . . . because either [he] wasn't careful, or I wasn't careful [doing the simulations]" (P_MC_December18). Here, Professor Poole again articulates his awareness of the imagined medical physics audience who may request raw evidence supporting his claim in the journal letter. But the statement that Professor Poole makes also points to his awareness of a second imagined audience: his future self. He is aware that in the future

he may have to defend his claims, and must thus produce the lab book files to be able to read and interpret both his results and how he arrived at them.

Again, the lab book is written so that not only an imagined audience within medical physics will be able to read and interpret its contents, but also so that the writer of the lab book can read and interpret its contents. The imagined audience (Bakhtin, 1986) of the lab book thus functions as a means of ensuring the lab book is readable, and thus *useable* by not only the physicists' future selves, but also by other members of the medical physics community. Therefore, while the most common audience of the lab book is its author's future self (in fact, this is how junior medical physicists are trained to write in their books), the lab book can be written for other physicists as well, such as collaborators, or as evidence in the event a claim is challenged.

Medium. As previously discussed (see Chapter Four), the participants in CRU's medical physics unit produce lab books in either a paper or electronic medium (see Figure 5.5). Although there may be a difference in the medium of the lab book, I argue that regardless of whether the lab books are paper or electronic, they belong to the same genre because the social situation in which the lab books are produced, the purpose, and the intended audience of the lab books are the same.

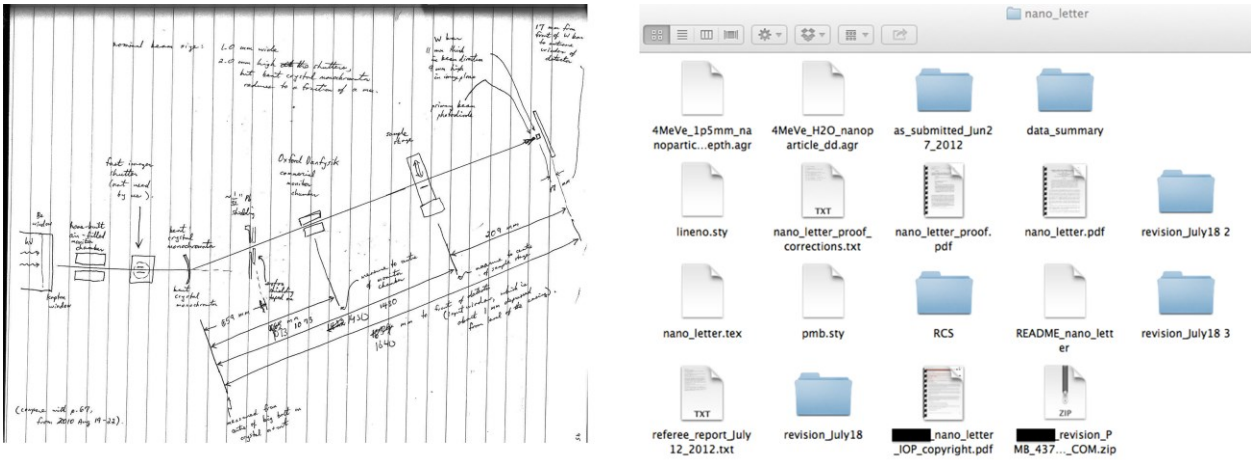


Figure 5.5. Paper versus electronic lab books. This figure shows an excerpt from Professor Burke’s paper lab book (left) and a subdirectory from Professor Poole’s electronic lab book (right).

While the medium of the lab book may change, its contents seem fairly similar across both paper and electronic book, as evidenced in the coding tree presented in Figure 5.6. Depending on the purpose of a particular entry, which is further discussed below, as well as the nature of the experimental work, the contents of a lab book entry range from drawings of x-ray schematics, to written notes, to graphs. Since a great deal of the experimental work that the medical physicists do at CRU is computational, that is, it entails simulating x-rays and radiation therapies on a computer, all of the lab books include filenames of a particular experiment, often accompanied by either a graph or notes about the work.

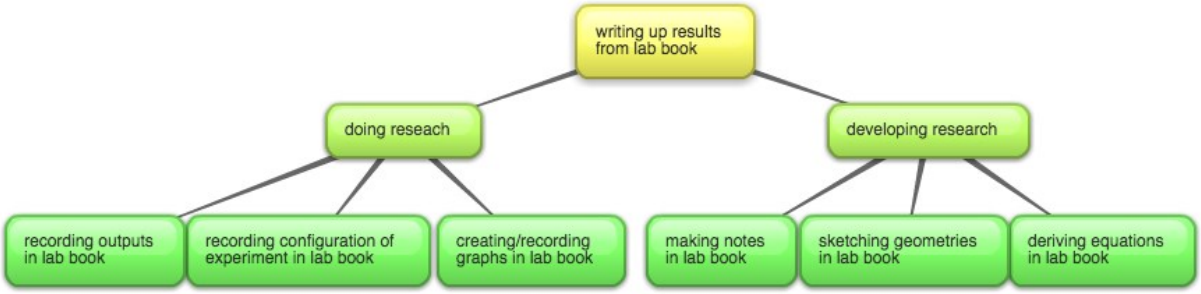


Figure 5.6. Rhetorical purposes coding tree. This figure shows the purposes (first and second level themes) and contents (third level categories) of both paper and electronic lab books.

Purpose. The purpose of the lab book within the social situation of the medical physics labs at CRU is one of the most important defining features of the genre. In fact, a genre's purpose and social situation are crucial in describing a genre (Bawarshi & Reiff, 2010) (for a more detailed discussion regarding the social perspective of genre, see Chapter Two). The lab book, be it paper or electronic, has several important purposes within the AS of the medical physics lab. Here, I view the lab book as multi-purpose social artefact, which is used in the medical physics lab for a variety of purposes: to facilitate the research process, to facilitate the writing of more visible knowledge-making genres (e.g., conference papers, journal articles), and to facilitate teaching and learning within medical physics labs.

Facilitating research. One of the main purposes of the lab book is its role as a heuristic that facilitates and records the research that goes on in medical physics labs. There are several different ways in which the lab book is used as a facilitative device in laboratory research, and in this thesis I focus on the three purposes that recurred during both initial interview coding and the analysis of the lab book. The first way in which the lab book facilitates research is what I refer to as the "puzzling out" stage. By this, I mean

that the participants used the lab book as a space to solve problems that they came across when doing research. The actual "puzzling out" of these problems often includes deriving equations for experimental work, calculating geometries used for imaging, calculating geometries for simulations, and solving roadblocks that occur during the research process. The second way the lab book facilitates research is planning research. The third purpose of the lab book in facilitating research is the recording of experimental results.

The lab book is an important tool within the activity system of the medical physics community because this is where a great deal of the "puzzling out" happens. In fact, when Sean needs to derive calculations and find solutions to research problems a great deal of the planning and deriving is in his lab book (S_INT1_July21). Sean's lab book includes a particularly good example of this purpose of the genre. An entry on research focusing on imaging and reconstructing geometries in a computer simulation can be found in Figure 5.7, which presents an example of this particular purpose. In this entry, Sean is trying to determine which part of a PET scanner is being activated by a PeTracker, a small radioactive marker, in a patient. Using a simulated PET scanner and a simulated cardiac patient, Sean is attempting to follow the movement of the PeTracker. This marker tracks the movement of a patient during a heart scan so that the resulting image, which is often very blurry, can be corrected (i.e., sharpened to reduce blurriness and produce a more accurate image) to account for the patient's movement. However, the tracker functions by sending signals to the scanner, meaning the data from the tracker are never collected in real time, which creates difficulty when Sean attempts to correct the image for the patient's movement. Figure 5.7 shows how Sean uses his lab book to solve this issue. On the left page, Sean has sketched the angles that the tracker currently

follows. Beneath this, Sean has derived equations to calculate a way of determining how to predict the tracker’s future location. At the top of the right page is a sketch depicting the angles that will allow Sean to calculate where the tracker will be located in real time (see Figure 5.7) (S_MC_December11).

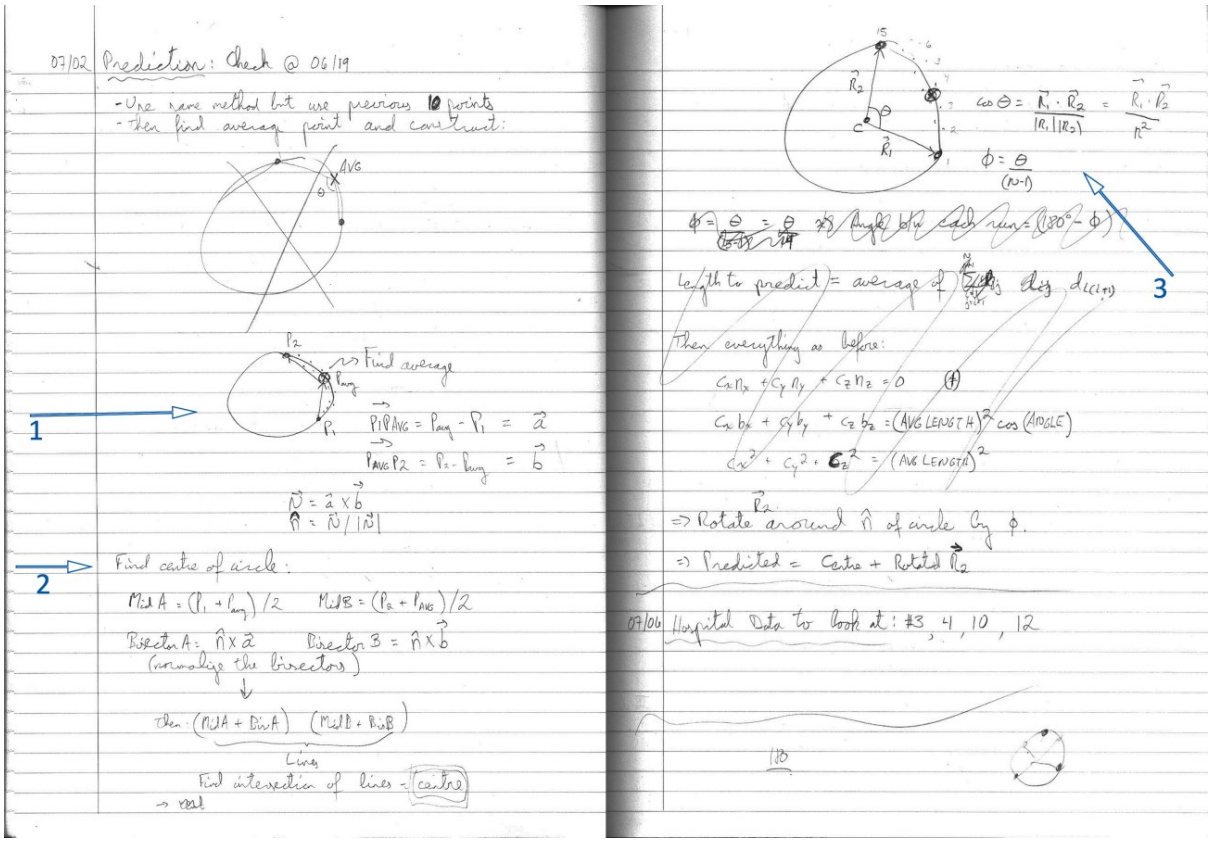


Figure 5.7. Sean’s lab book excerpt showing the deductive process used to calculate the motion of the PeTrack marker. This figure illustrates the initial sketch (1), problem to be solved (2), and the solution (3).

In addition to playing an important role in the stage of the research where physicists work to derive equations and solve problems, the lab book facilitates research by acting as a tool to plan research and determine its feasibility. Professor Burke’s lab book is an especially good example of how the lab book impacts the planning of research, not only for Professor Burke, but for his students as well. In fact, the lab book that

Professor Burke shared with me for this study contained information about a project that he and one of his graduate students had worked on in the past. This graduate student was working on developing a scatter imaging system using a sophisticated and high tech radiation source located in another Canadian province, which operates twenty four hours a day. In this case, the two had access to the technology for only thirty-six hours. Professor Burke explained to me that, for that particular project, he took on the role of recording plans, objectives, and schematic drawings in the lab book, both before and during the experimental work (B_INT1_July9). For this particular project, it was extremely important for the experimental work to be planned out ahead of time in the lab book because, as Professor Burke told me, "if a student and I fly to [another province] and haul some equipment there and we have access to the machine for thirty-six hours and we end up with a bunch of nonsense, that's a big waste" (B_INT1_July9). Since this project was so high-stakes, in that it necessitated Professor Burke and his student to travel in order to have the radiation source for thirty-six hours, the lab book served a crucial role in planning and facilitating the research. Without the plans recorded in the lab book ahead of the actual experimental work, it would have been necessary to spend a great deal of time at the radiation source creating the objectives and plans. In addition, Professor Burke and his student worked in shifts, so the lab book also served as a record of the work that had been done, the filenames containing the experimental work, as well as the conditions and dimensions of the technology itself. In this instance, the lab books served a very important purpose in facilitating Professor Burke and his student's research. The lab book not only functioned as a tool to plan out the research project before accessing the radiation source, it also facilitated the collaborative nature of the project, coordinating

their work and ensuring that they were able to meet the objectives they had set for the project.

In addition to planning high-stakes experimental research, lab books are also used to record trial experiments that professional academic medical physicists and their colleagues will perform to see if the work is feasible for a student in the field. These trial experiments are called "prototypes" (B_INT1_July9). For instance, Professor Burke showed me entries in his lab book that recorded a prototype experiment he worked on with Dr. Lee. In this case, the two were attempting to work on capturing x-ray scatter patterns on a detector in Dr. Lee's lab. The entry recorded a schematic drawing of the experimental set-up, as well as names of computer files the two kept, hypotheses for why the prototype was unsuccessful, as well as improvements that could be made on a subsequent attempt. Professor Burke explained that documenting the prototypes is important for facilitating research because it allows him to determine whether or not it would be worthwhile to collaborate with a student researcher on a project: "we took two days and decided we had problems doing [the experiment]. If we had given it to a student, they would have thrashed around for two months and . . . it would have been bad" (B_INT1_July9). Thus, keeping track of prototypes helps facilitate research by determining whether or not a full-scale project would be doable and worthwhile.

As mentioned above, a great deal of the research that goes on in the participants' labs is computational, that is conducted using computer simulations. Due to the nature of this research, the initial results of an experiment tend to be numerical. For example, Professor Poole explained that for much of his work, his initial research results are located in a long line of numerical output generated by the simulation that is called the

“listing file” (P_INT1_August19). The listing file is frequently then further analysed, often by graphing the results (P_INT1_August19). Since the results of these computational experiments can be quite long, many participants explained, “it just doesn’t seem to be practical to be writing [the initial results in the lab book]” (L_INT1_July25). Because of the length of the listing files, the participants do not find it to be worthwhile rewriting the results by hand in their lab books, or even printing and stapling the output into their lab books. Instead, participants record the *filenames* of the results of their experiments into the lab book, enabling the participants to easily locate the file containing their results. As Dr. Lee explained, “we always have: what have we done, what’s the study for . . . and the filenames, the date, the time-stamp, what time we did the [simulation], which folder . . . We write [it all] down in the lab book. That’s how we trace the files down” (L_INT1_July25). Because the numerical results are quite long, it is important the physicists have a way to record the information so that they both know where the digital results are stored and what experiment it was associated with. In addition, the computational nature of a great deal of medical physics research results in a large number of files storing results, simulations, and notes. Because of the immense amount of data that the participants work with, it is important to be able to track down, or as Dr. Lee says “trace”, the necessary files quickly and easily.

In addition to recording and storing the results of the project, the lab book is also used to record information about the format of data files and simulation coordinate systems, known as standards, as well as equipment used in research projects. As Dr. Britney clarified:

> Probably you wouldn't believe this, but we spend so much time trying to get data from one format into another format. So, data that we're given from the hospital, it's never just plug it in and go. It's, okay, what format is this in? Is this the right coordinate system? That sort of thing. (Br_INT1_July9)

Here, Dr. Britney explains an essential step in her research: identifying the format of data files that she will subsequently simulate and use in her research. Not only Dr. Britney experiences this problem when doing research; almost all participants encounter issues with file formats and coordinate systems. Without having the correct file formats for data and the correct coordinate system, they cannot accurately simulate patient treatments, nor can they examine novel ways of treating or scanning patients.

In order to overcome this issue, the participants' lab books include detailed records of information not only on file formats used in hospitals and clinics, but also on the coordinate systems of different scanners. This way, whenever they need to create a program to run a simulation or convert a file into a format that is appropriate for their research, the records of how to convert both coordinates and files are easily accessible. For example, as mentioned above, in Sean's research with a local cardiovascular institute he needs a great deal of detailed information about the coordinates that the scanner uses when producing images. Since he uses this information on a fairly regular basis when doing research, he uses his lab book as a way to keep a record of the detailed scanner information (S_INT1_July 21). In this way, the lab book serves the purpose of being a record-keeping device. In addition to the puzzling out and planning, all of the participants in this study used the lab book as a repository for important records, such as results of

experiments, notes from meetings with research collaborators, as well as information about lab equipment.

The lab book's role in facilitating research and keeping records of image standards and equipment specifications denotes the lab book as a key locus of knowledge-making activity. As displayed in Figure 5.8, the lab book can be seen as serving as a mediating artefact in research and record keeping activity within the medical physics labs. In these figures, I represent only the production sphere of Engeström's (1987) expanded mediational triangle (see Figure 6.20). This is because, at this point in my analysis, I am mainly concerned with how the lab book was produced as a mediational artefact in order to achieve a particular outcome. I draw on Engeström's expanded triangle in the discussion of my analysis and findings.

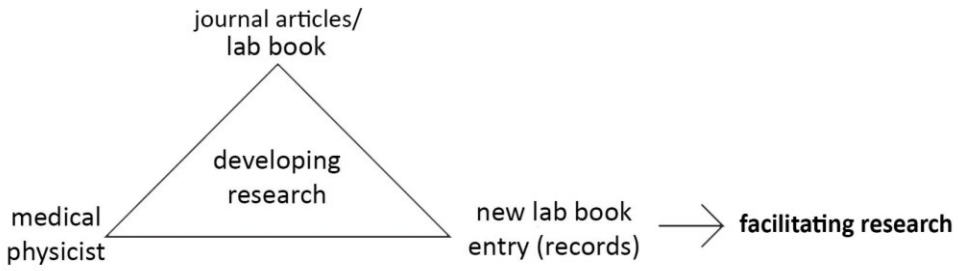


Figure 5.8. Developing research. This figure illustrates an activity triangle depicting the activity of developing research using the lab book as a mediating artefact.

Figure 5.8 maps the activity that takes place when the lab book is utilised as a heuristic device for facilitating research and keeping records in a medical physics lab. When developing new simulations or imaging experiments, the medical physicist (occupying the subject position in the activity triangle) draws on both old lab book entries and journal articles as mediational artefacts to act on the object of the activity: a new lab book entry developing a new simulation or experiment. After a new lab book entry has

been created to plan and develop the new research, the following activity will likely consist of the medical physicists as a subject, drawing on the lab book entry created in the previous activity system as a mediating artefact, in order to produce another new lab book entry detailing the results of the simulation of experiment (see Figure 5.9).

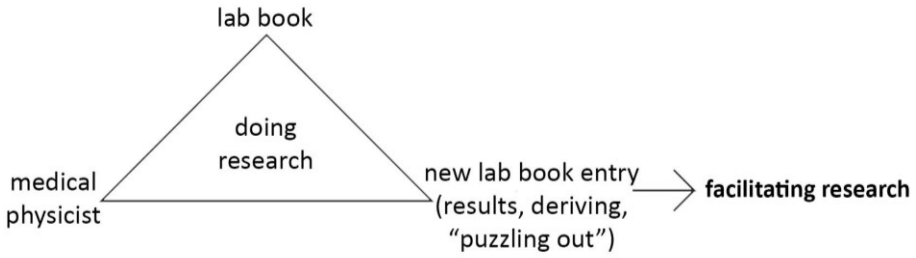


Figure 5.9. Doing research. This figure illustrates an activity triangle depicting the activity of doing and refining research.

Often, the simulation or experimental results produced in the activity system illustrated in Figure 5.9 will be modified or changed in order to correct issues in the simulation code or in the experimental process. The changes in the simulation code or in the experimental process will again allow a new activity to develop, again with the lab book occupying the mediational artefact position in the activity, with a new lab book entry recording results as the object of the activity (see Figure 5.10).

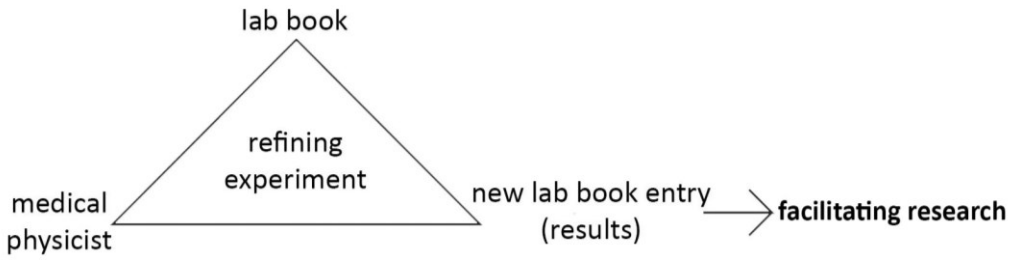


Figure 5.10. Refining the experiment. This figure illustrates an activity triangle depicting the activity of refining experiments, which produces a new lab book entry.

The activities depicted in Figures 5.8, 5.9, and 5.10 demonstrate how the genre of the lab book is used as a mediational artefact that facilitates research and acts as a heuristic for the medical physicists when they do their research. Figure 5.11 shows how these activities combine with the ultimate outcome of knowledge creation.

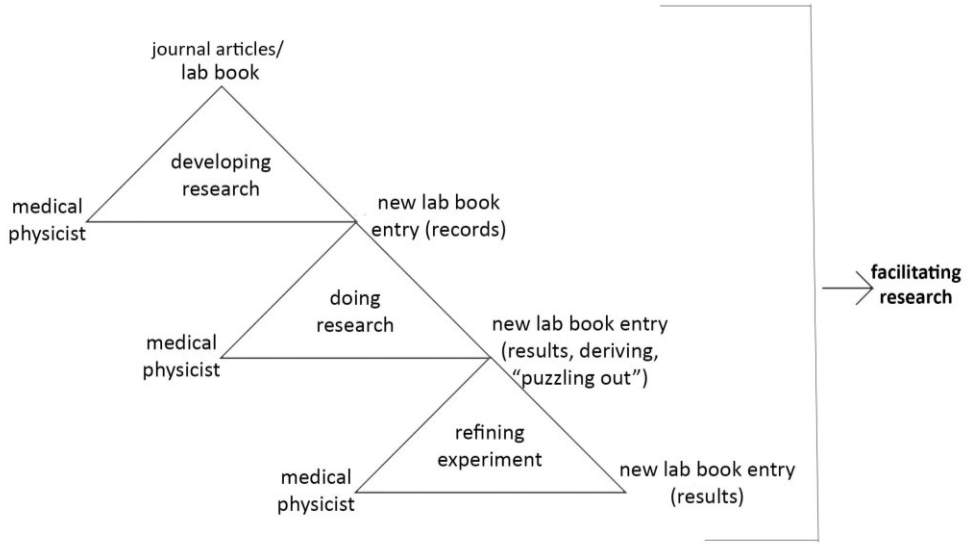


Figure 5.11. Facilitating research. This figure illustrates activity triangles depicting the role of the lab book as a mediating artefact in facilitating research.

Facilitating writing. Another purpose of the lab book is that it often serves as a starting point for the writing process of other genres, like conference papers, journal articles, or journal comments. That is, the lab book facilitates the writing process of the

medical physicists. As mentioned above, the lab book also serves as a record keeping and research tool, commonly used when starting to write other more visible genres. When I asked Dr. Britney about the kinds of documents she draws on when writing genres like journal articles, she described how she often starts “with the [lab book] to get the general ideas” (Br_INT1_July9). Dr. Britney explained to me that most of the initial ideas for research projects are recorded in her lab book, so when she begins to write new texts, which range from conference proposals to funding grants to journal texts, she often begins with the ideas recorded in her lab book (Br_INT1_July9). In this way, the lab book serves a very important purpose in Dr. Britney’s work because it acts as a starting point for the creation of other genres that she regularly produces.

Sean also uses the lab book as a starting point for producing other texts, such as conference proposals, conference papers, and journal articles. When conducting an experiment, Sean stated, “ I write down whatever parts I need in my lab book, and eventually this became an abstract . . . these [lab book entries] will become one of my PowerPoint, reference PowerPoints. A combination of those might become a talk eventually” (S_INT1_July21). Sean demonstrated an additional example of a conference abstract that he had submitted just before my first interview with him. He showed me the abstract he had written in addition to a series of lab book entries on the same project and explained that the abstract he submitted had grown out of the notes in his lab book. Like Dr. Britney, then, Sean’s lab book serves an important purpose in facilitating the writing of other genres.

Like Dr. Britney’s and Sean’s paper lab books, Professor Poole’s electronic lab book also facilitates the writing of other genres; however, since Professor Poole’s

research is almost entirely computational, the lab book is used in a slightly different way when writing up conference or journal articles. When I asked Professor Poole about the writing process of documents like journal articles, he explained that he always advises his students to start by getting all of their results into one document (P_INT1_August19). As explained above, Professor Poole’s electronic lab book is basically a collection of subdirectories for all of the projects that he has worked on. These subdirectories include comprehensive Excel, text, and graph files that record, explain, and visually present the numerical results of his research. In this case, Professor Poole uses his electronic lab book as a starting point for the creation of other genres because it is within the genre of the lab book that he keeps all of the results (P_INT1_August19). According to Professor Poole, “that’s what the paper’s for, is to put your results out there” (P_INT1_August19). The electronic lab book facilitates Professor Poole’s writing of other texts because not only does the lab book contain the results that are so crucial to genres like the journal article, but also because it contains the visual representations of these results, the importance of which I discuss further.

Like its role as a mediational artefact facilitating research, the lab book is also an important mediational artefact in the production, or writing up, of more visible knowledge-making genres within the activity of the medical physics labs. As shown in Figure 5.12, the lab book is used by academic medical physicists in order to start producing genres that are disseminated amongst the wider medical physics CoP (e.g., Beaufort, 1997; Myers, 1985a). The ultimate outcome of this activity is, I would argue, knowledge construction. The experiments and simulations that are recorded in the lab

book are transformed into knowledge-making texts that are shared with a large medical physics community, as shown in Figure 5.12.

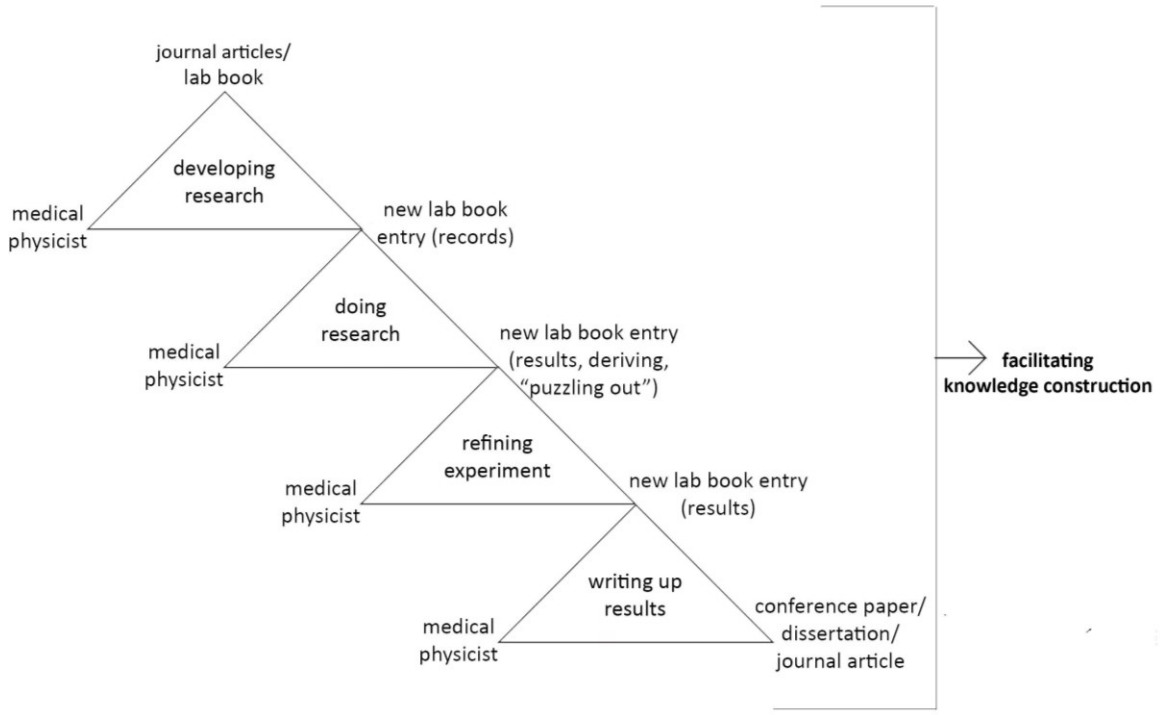


Figure 5.12. Facilitating knowledge construction. This figure illustrates activity triangles representing how the research process and writing up process leads to knowledge construction.

Facilitating teaching and learning. A third purpose of the lab book is the role that it plays in both the teaching and learning of novices, or as Professor Burke calls them "trainees", in medical physics. Students in medical physics are tasked with keeping lab books early on in their academic career. At the time of this study, Professor Burke was working on simulating x-ray scattering patterns with an undergraduate summer student, who was expected to keep a lab book detailing the planning he had been doing for, as well as the work he had been doing on, the project. Professor Burke told me about a specific case where he and his student needed to derive an equation for their simulation,

so they worked out the derivation together on a piece of scrap paper. After this, Professor Burke expected his student to “put [the equation] in his logbook and [understand] it” (B_INT1_July9). In this case, the lab book is being used as a learning and teaching device. Not only is Professor Burke teaching his student how to derive equations, he is also teaching the student how to use the lab book as a means of facilitating the research process. By teaching the student to use the lab book as a repository of calculations and research work, Professor Burke is training the student to use the lab book like a professional academic medical physicist.

The teaching and learning purpose of the lab book goes beyond simply enabling the training of novice medical physicists, it also enables collaboration and teaching amongst more experienced members of the discipline. For instance, Professor Poole also uses the lab book as a means of facilitating teaching and learning. Because so much of Professor Poole’s work, and by consequence his students’ work, is computational, he and his students tend to keep electronic lab books. Along with the aforementioned drafts of articles, these electronic lab books also contain Microsoft Excel spreadsheets with results of experiments and simulations. When I asked Professor Poole about whether he and his students used their lab books as a starting point when writing conference and journal papers, he explained that for the most recent paper he and his research team, which consisted of graduate students and a post-doctoral fellow, were working on “the postdoc who was writing had a whole slew of Excel spreadsheets and every once in a while I would ask him to give me one because I wanted to check how he had interpreted something” (P_INT1_August19). The Excel files included in the post-doctoral fellow’s lab book enabled Professor Poole to ensure that a more experienced post-doctoral fellow

was interpreting results appropriately. While not teaching the basic rules of how to keep a lab book and the functions of the genre, in this case Professor Poole was able to take advantage of the lab book’s purpose of research facilitation to ensure that results were being interpreted correctly. The lab book also allowed him, if necessary, to correct and teach the proper method of interpreting the data in the Excel file. Thus, the lab book can be used by senior expert mentors to teach more experienced medical physicists about knowledge within the field.

Again in this case, the lab book acts as a mediating artefact that enables both the teaching of and learning by more novice members of the medical physics community. Figure 5.13 shows how senior medical physicists, like Professor Poole and Professor Burke, use the lab book as an aide to train novice medical physicists in the ways of knowing and doing in the medical physics CoP. In addition, the lab book serves as a mediating tool for students to learn about how to derive equations, keep proper records of research, and be members of the field. I would argue though that unlike the previous two rhetorical purposes of the lab book (facilitating research and facilitating writing), the ultimate outcome of this activity is not knowledge construction. Instead, I would argue that the outcome of the activity is identity construction and maintenance.

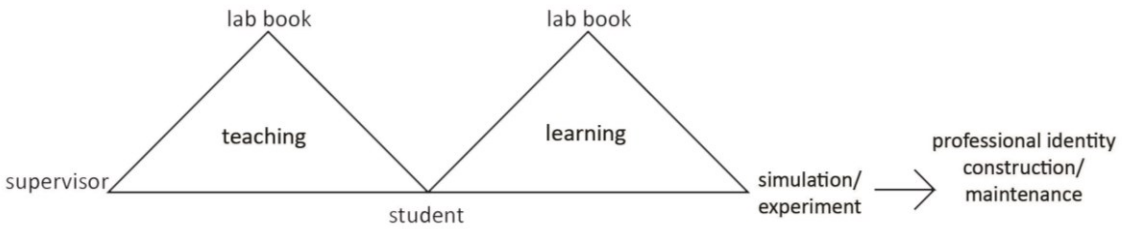


Figure 5.13. Identity construction and maintenance activity triangles. This figure depicts how the lab book is used as a mediating artefact in teaching and learning, with the ultimate outcome being professional identity construction and maintenance.

As I discuss further (see Chapter Six), when the professional academic medical physicists in my study discuss the lab book as a tool that helps them teach novice members of the field, they are reinforcing their own identities as teachers and mentors to new members of the CoP (see Figure 5.3 for a coding tree demonstrating the connection between teaching and identity). When students are trained to use the lab book, they are not only learning how to be a member of their CoP through the implicit ways of knowing and doing embedded in the genre of the lab book, they are also developing their own identities within the field. I would argue that this is case when students learn about medical physics from their mentor with their lab books, and then go on to reproduce or modify an experiment or simulation her- or himself and record the results in a new lab book entry. In this way, the students are developing their own identities as researchers in the local medical physics lab at CRU (see Figure 5.13).

Multimodal Analysis and Findings

The multimodal nature of the lab book assists members of the medical physics community in appropriately responding to this knowledge-making exigence. By that, I mean that the various semiotic modes found in the lab book (e.g., visuals, text, mathematical notation) are necessary to the creation of knowledge in the field. In the

following paragraphs, I present an analysis of how the modal intensity, complexity, and density of my participants’ lab books serve to facilitate the high level action of knowledge construction and mobilisation.

In order to analyse the lab book’s multimodality, it was necessary for me to return to my interview coding trees. When participants explained how they used their lab books, which I subsequently conceptualised as the purposes of the genre (see Figure 5.3), they showed me how sketches, graphs, mathematical equations, and text all functioned together to make the lab book easy to read and use. In fact, when I asked Sean, Dr. Britney, and Professor Poole about the multimodal nature of their lab books during our member check interviews, they confirmed the necessity of having both text and non-text in each lab book entry. Below, I use MMI (Norris, 2004a) to analyse sketches and graphs in the lab books of Sean, Dr. Britney, and Professor Poole. I made an informed decision to focus my multimodal analysis on the visual modes of sketches and graphs because they were the most common multimodal features discussed by participants in both interviews and member checks. Before presenting the multimodal analysis, I should point out that mathematical equations also play an important role in the lab book’s facilitation of knowledge construction. However, in the lab book entries I analysed, sketches tended to facilitate the derivation of mathematics equations. Therefore, I do not analyse the mathematics present in the lab book entries, but instead focus on sketches and graphs.

Modal intensity. Analysis began with examining the entries of the participants’ lab books. More specifically, I began with examining whether or not the entries of the lab books contained any modes that had a particularly strong impact on the purpose of the lab book entry, a feature Norris (2004a) calls “modal intensity” (p. 83). A mode with high

intensity will have a larger impact on the action being performed, whereas a mode with low intensity will have little to no effect on the rhetorical action being performed (Norris, 2004a, p. 83). I should point out here that while some modes in a lab book entry may be modally intense, it does not mean that other modes are not important. I use modal intensity to refer to modes that facilitate other modes. That is, a high-intensity mode will facilitate other low-intensity modes coming into being. Let me illustrate this with an example from Sean’s lab book.

Figure 5.14 shows the entry from Sean’s lab book where he is trying to determine the correct angles to predict the future location of the PeTracker.

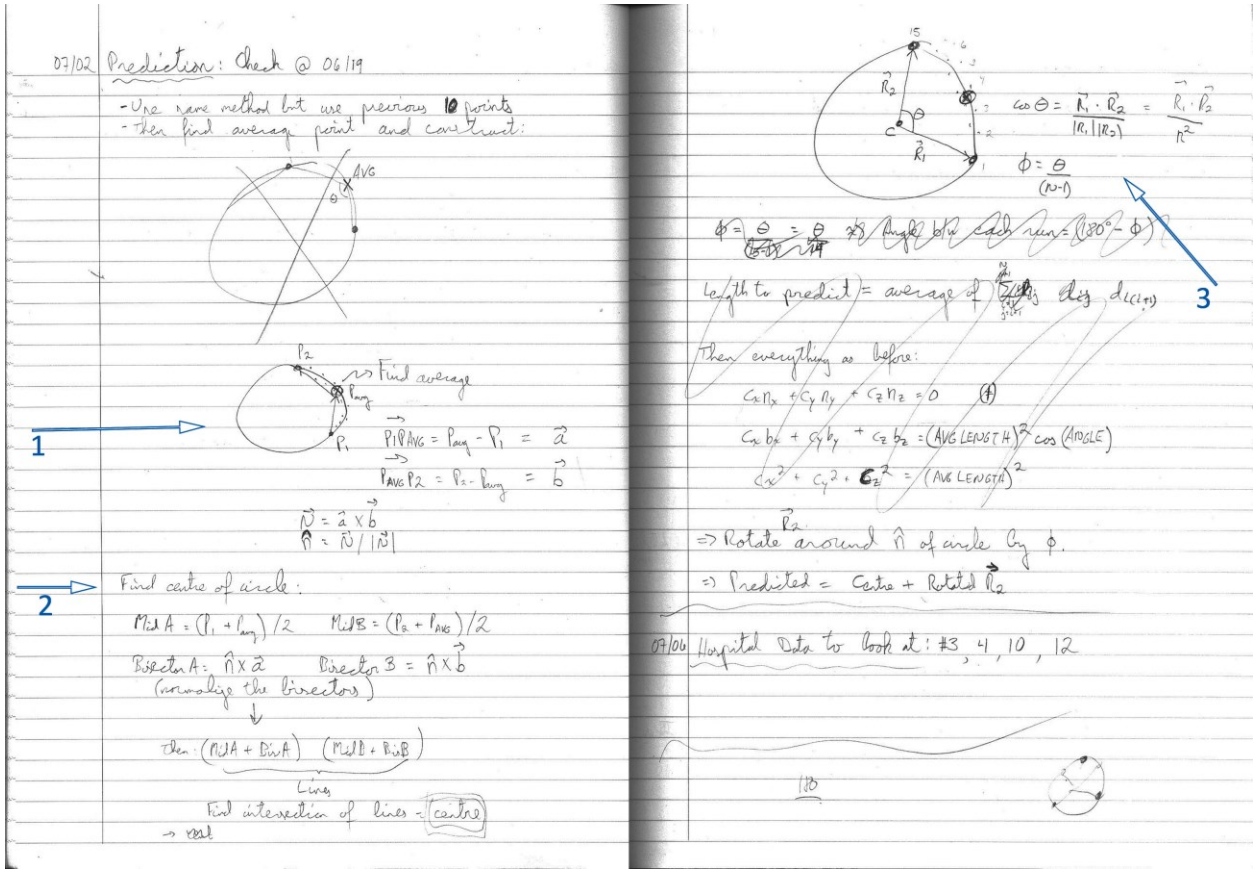


Figure 5.14. An excerpt from Sean’s lab book. This lab book entry shows modally intense sketches (1 and 3) and less modally intense mathematics problem (2).

Above, I analysed this particular entry’s purpose within the lab book as a heuristic that facilitates Sean’s research, specifically his ability to solve a problem he encountered doing the research.

During the initial multimodal analysis of the lab book, I identified the visual modes in this entry, the geometry sketches, as having high modal intensity, whereas the mathematics problem had a low modal intensity. The lab book entry seemed structured in such a way that the initial sketch (Figure 5.14, 1) facilitated the existence of the mathematics notations (Figure 5.14, 2). In other words, the initial problem sketch in the entry acted as a heuristic that allowed Sean to determine the kind of mathematics he

would need to derive the solution to his problem. Without the initial sketch, Sean would not have had a guide to determining the angles he needed to calculate. The lab book’s ability to facilitate the achievement of facilitating research comes from the multimodal nature of the book, in particular, the visual modes in the entry.

The high modal intensity of the visual modes (sketches) in this lab book entry was confirmed by Sean during a member check interview (S_MC_December11). When asked about whether or not the entry would suit the same purpose and be readable without any of the drawings, notes, or mathematics, Sean explained that in this entry, the sketches were especially important (S_MC_December11). In this entry, the sketches at the top of the page are of higher modal intensity than the mathematical equations because the sketches determined what mathematical equations Sean would use to solve the research problem he encountered (S_MC_December11). Although the mathematics notations are an important mode within the entry, I would argue that since the sketches helped Sean determine the math he needed to use, the sketches take on primacy within the entry. The sketches structure the entry (Norris, 2004a), that is, they enable Sean to subsequently derive the formulas to accurately correct for the scanner’s lag in data transmission. Thus, in this entry, visual modes are more modally intense than the written and mathematics modes.

Dr. Britney’s lab book also contains evidence of the high modal intensity that visual modes tend to take. Figure 5.15 shows an entry from Dr. Britney’s lab book, in which she is converting data from a patient’s treatment into coordinates she can use to run a simulation of the radiation therapy. Again, because the importance of non-textual

modes was discussed by all participants, I analysed the lab book entry to determine how the different modes created meaning within the entry.

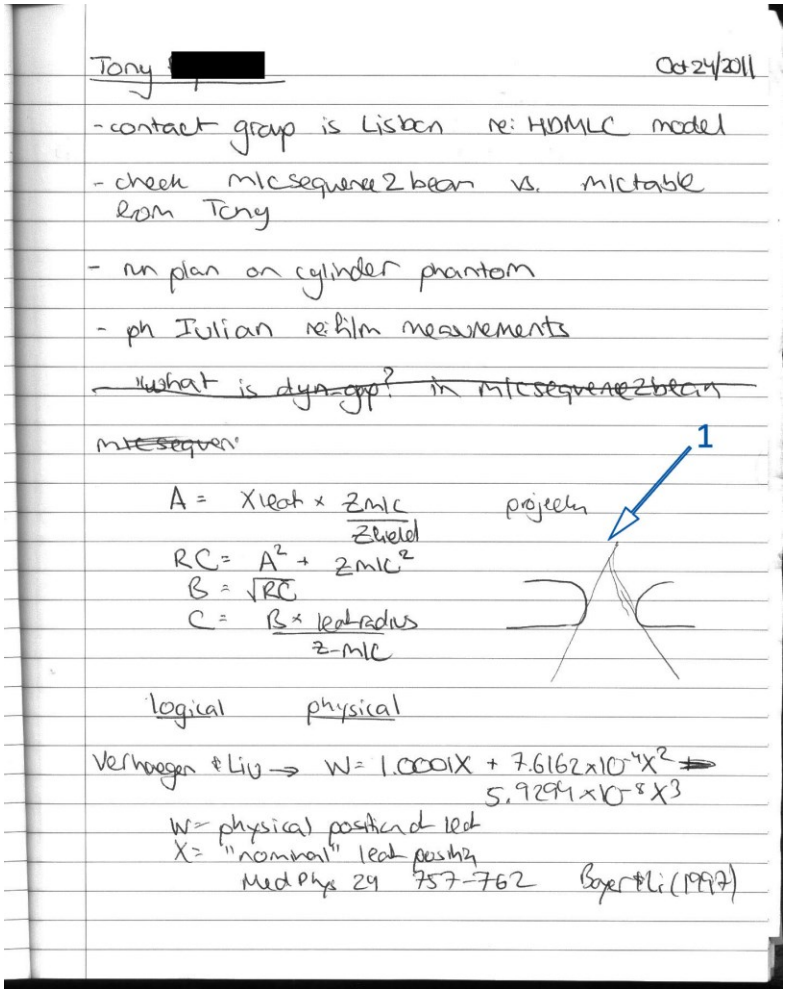


Figure 5.15. An excerpt from Dr. Britney’s lab book. This excerpt shows a sketch (1) representing a geometry projection used in Dr. Britney’s research.

Like in Sean’s entry, which I discussed above, I analysed the visual mode (the sketch) as having a higher modal intensity than the surrounding text and mathematics notation. Again, during the initial analysis, I viewed the visual mode as facilitating the mathematics formula that is included in the entry, in addition to the following steps taken to analyse the patient’s treatment. When I asked Dr. Britney about the different modes on the page, she explained that, in this case the visual did not carry the high-intensity that I

had believed from my initial analysis (BR_MC_February2). She also clarified the reason why the particular sketch in the entry was not as important: this sketch represents a geometry projection that Dr. Britney uses on a regular basis (Br_MC_February2). She explained that if she were not as familiar with deriving the geometry in her simulations, the visual mode would be one of the more important features on the page. Despite the fact that in this particular entry the visual mode does not carry high intensity, Dr. Britney revealed that visual modes, in her lab book, tend to be extremely important because in her research “it’s hard to describe things in words . . . sketches are a big deal” (Br_MC_February2). Thus, while the visual mode in this particular entry does not take on a high modal intensity, I would argue that Dr. Britney’s discussion about how visual modes are often necessary in facilitating research indicates that visual modes are likely to take on high intensity in lab book entries.

In fact, the participants all seemed acutely aware of the importance of visual modes in the lab books, especially in facilitating the role of the lab book as a research heuristic that helps the medical physicists solve problems they encounter in their research. Dr. Britney, for instance, explained, “in the logbook they [visuals] take on more of a primary role” partly because she finds that the visuals help her recall information more easily in addition to succinctly recording a complicated idea during the “idea stage” (Br_INT1_July9). Sean also explained that drawing a geometry diagram in his lab book and using that drawing to figure out what he needs to do next in his research process was very important (S_INT1_July21).

Modal complexity. While there are some lab book entries where one mode, often a visual mode, takes on a higher intensity than others, many of the entries do not have

one mode that takes on high modal intensity. Instead, in many of the lab book entries a variety of different modes, such as visual modes (e.g., sketches, diagrams, graphs), mathematical modes, and written modes, are used together in order to make meaning. This combination of modes is referred to by Norris (2004a) as modal complexity, which she describes as the “interplay of many different communicative modes” (p. 87). The modes that make up a modally complex action are intricately intertwined and work together to make meaning. The following presents an analysis of the modal complexity within the lab books.

One example of modal complexity in the lab books can be found in Sean’s lab book. Figure 5.16 shows a portion entry from Sean’s lab book which records his first experiments with PeTrack (for the full entry, see Appendix D). In this entry, Sean has recorded the orientation of irradiated plates to be scanned using a PET scanner. The entry shows the orientation of plates (dark circles represent irradiated plates, light circles non-irradiated plates), filenames containing the results of each scan (e.g., p850s3_PET), the duration of the scan (e.g., 30s), as well as the distance from the centre of the scanner (e.g., ~2cm).

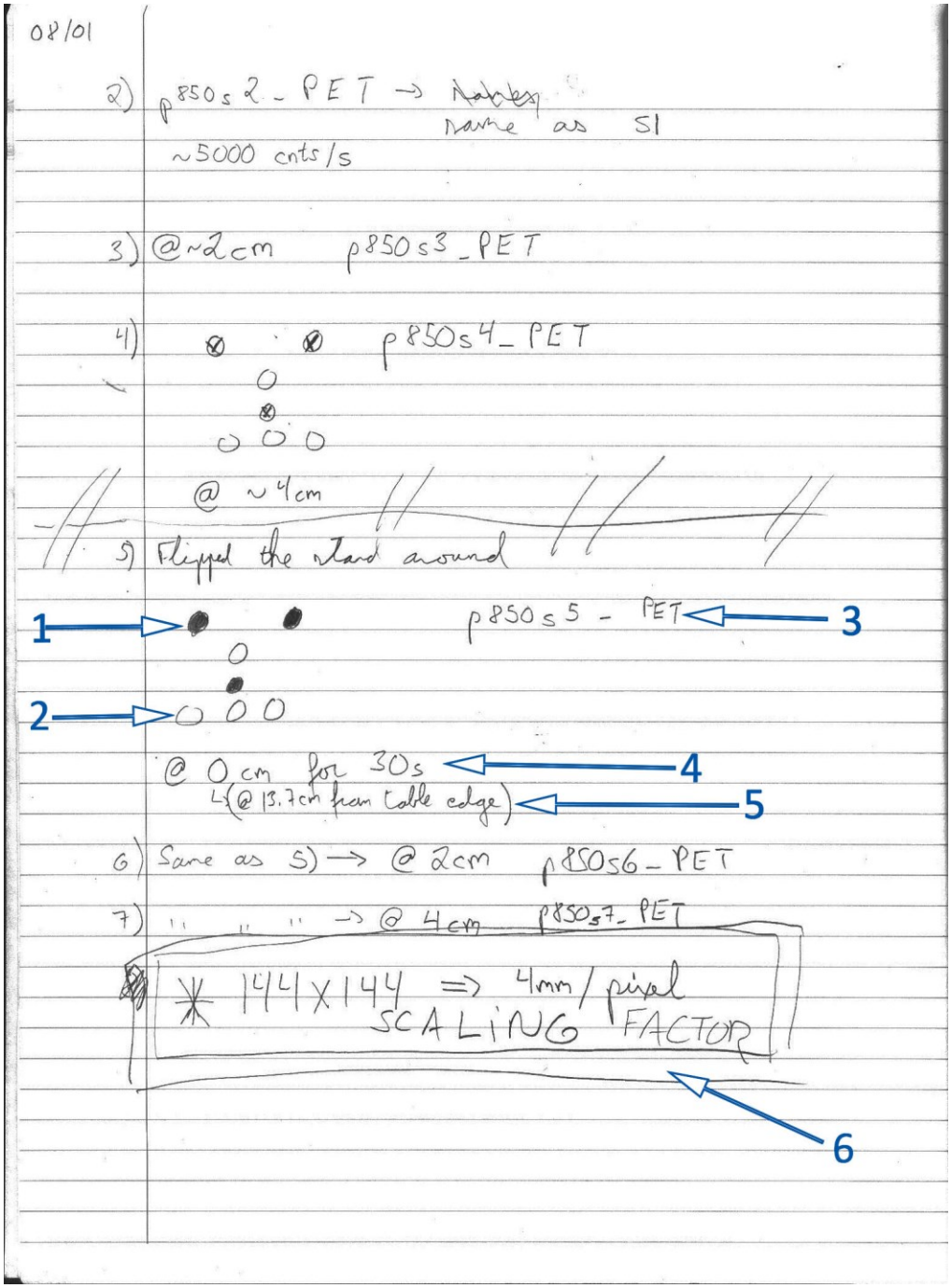


Figure 5.16. PeTrack lab book entry. An excerpt from Sean’s lab book showing the set-up of an experiment using a PET scanner with irradiated (1) and non-irradiated (2) plates, filenames (3), length of the scan time (4), location of the plates (5), and a note on the resulting scanned image (6).

When I questioned Sean about the meaning and purpose of the various modes in this lab book entry, Sean explained that all of the information was equally necessary because without it, he would be unable to recreate the experiment in a simulation (S_MC_December11). I interpreted all of the modes as being combined in order to achieve a particular purpose of the lab book. That is, the modes in the lab book entry shown in Figure 5.16 are equally important to achieving one of the purposes of the genre: without the images, Sean would not know the configuration of the plates in each scan, without the filenames, Sean would not be able to retrieve the results from the scans, and without the duration of the scan and the distance from the centre of the plate, Sean would not be able to recreate the scans in a phantom study (S_MC_December11). Not only do the modes combine to create a record of the experiment, they also serve as a means of facilitating future experimental scans. This entry from Sean’s book serves as an illustration of how modally complex many lab book entries are. Most of the entries in the lab books require the integration of several different modes in order to accomplish the purposes of the genre.

Modal complexity is also apparent in another lab book entry of Sean’s. Figure 5.17 shows an entry from Sean’s lab book recording a diagram of the PET scanner detector modules that he and his supervisor, Dr. Lee, use in their lab at CRU.

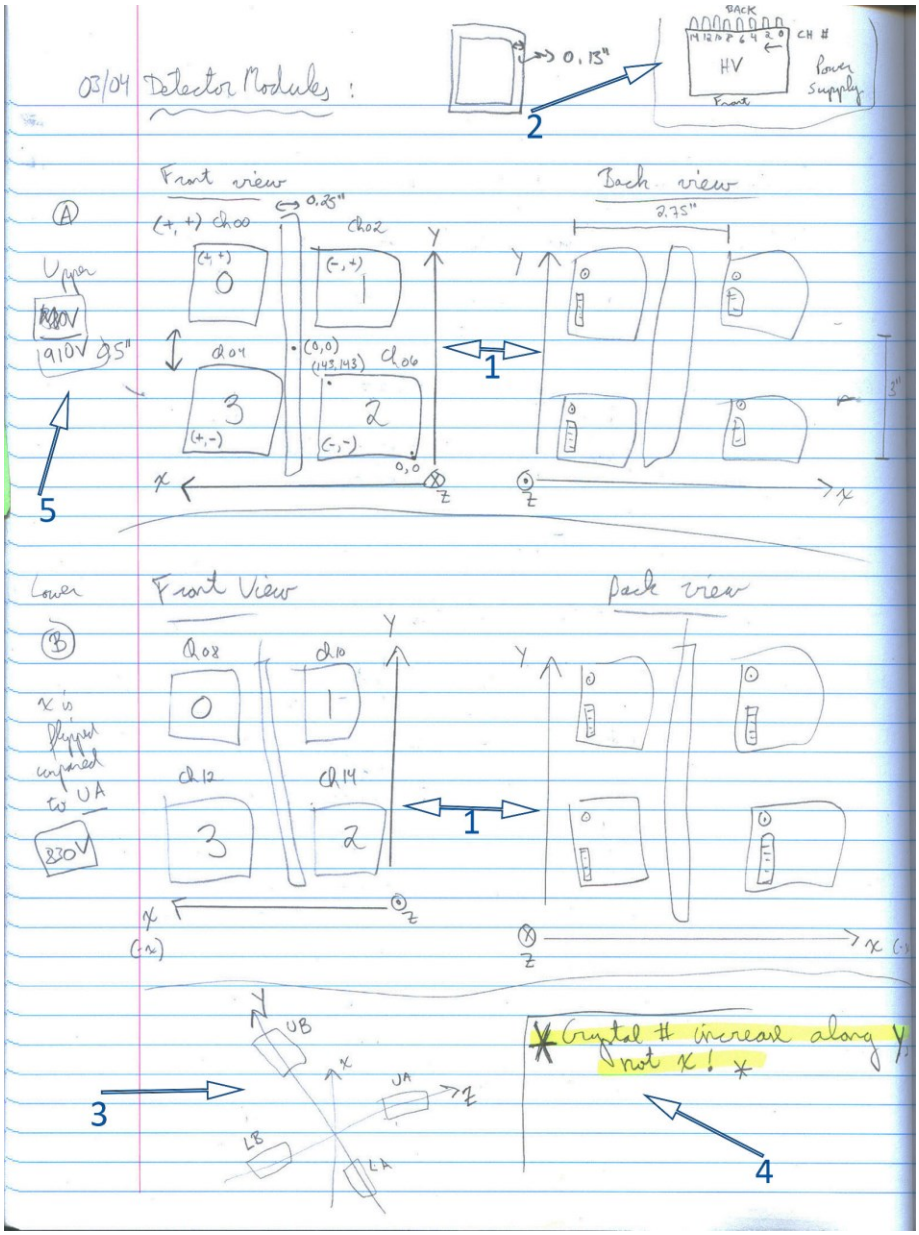


Figure 5.17. An excerpt from Sean’s lab book. This entry shows schematic drawings of detector modules (1) used in PeTrack experiments, a detail drawing of the scintillator crystals in the modules (2), the orientation of the modules in the lab (3), a note about determining the location of a specific scintillator crystal (4), and the voltage of the detector modules (5).

The diagram shown in Figure 5.17 appears to consist primarily of visual modes: drawings of the detector modules (Figure 5.17, 1), a detail drawing of the scintillator crystals that make up the interior of each detector module (Figure 5.17, 2), and the orientation of the detector modules in the lab (Figure 5.17, 3). On closer inspection, however, it becomes apparent that other modes, such as the written notes (Figure 5.17, 4), and the numerical dimensions (Figure 5.17, 5) are just as important to Sean being able to use the lab book entry effectively. During our member check interview, Sean explained that an entry like this would be used to recreate the detector modules in a simulation (S_MC_December11). When I asked him whether he would be able to use this entry to recreate the simulation using the visual modes alone, he described how the details in the entry, like the information about the voltage in each module, the orientation, and the dimensions, were very important (S_MC_December11). Without this information, he would be unable to accurately recreate a simulated detector. Each individual crystal in each detector module has its own identification coordinates and Sean needs to be able to identify which crystal is being activated during a scan, and “which detector goes with which crystal” (S_MC_December11). To deduce the crystal location, Sean needs to know how each crystal is numbered within the module, so he has made a written, highlighted, note in the bottom left of the entry as a reminder of how the crystals are organised (Figure 5.17, 4). Without this note, Sean may not remember how the crystals are organised in the detector. Thus, the entry can be said to be modally complex since all of the modes play a role in Sean’s ability to use this entry to recall information about the detector modules and recreate them in a simulation.

An additional example of graphs’ modal complexity can be found in Dr. Britney’s lab book (see Figure 5.18). This particular entry consists of a written page and a printed out graph that has been stapled into the book. In this entry, Dr. Britney is testing a modification that she has made to improve a standard simulation code. This graph compares both the standard code (DOSXYZ) and Dr. Britney’s modified code (4DdefDOSXYZ4). DOSXYZ is a standard Monte Carlo code that is used to calculate three-dimensional radiation doses in radiation therapy simulations, and Dr. Britney’s code, 4DdefDOSXYZ4, is the name of her modified version of the standard (Br_MC_February2). Both of the lines should match over the wide distribution of the graph, meaning the shape of both lines should be fairly similar. In the written entry of the book, Dr. Britney has recorded the exact changes that she has made to the original DOSXYZ code. For instance, Figure 5.18 records a change that Dr. Britney made to line 2736 of the original code (2). Additionally, Dr. Britney recorded the time it took to run both simulations (3), as well as a note about how long it took both codes to run on a different computer operating system (4).

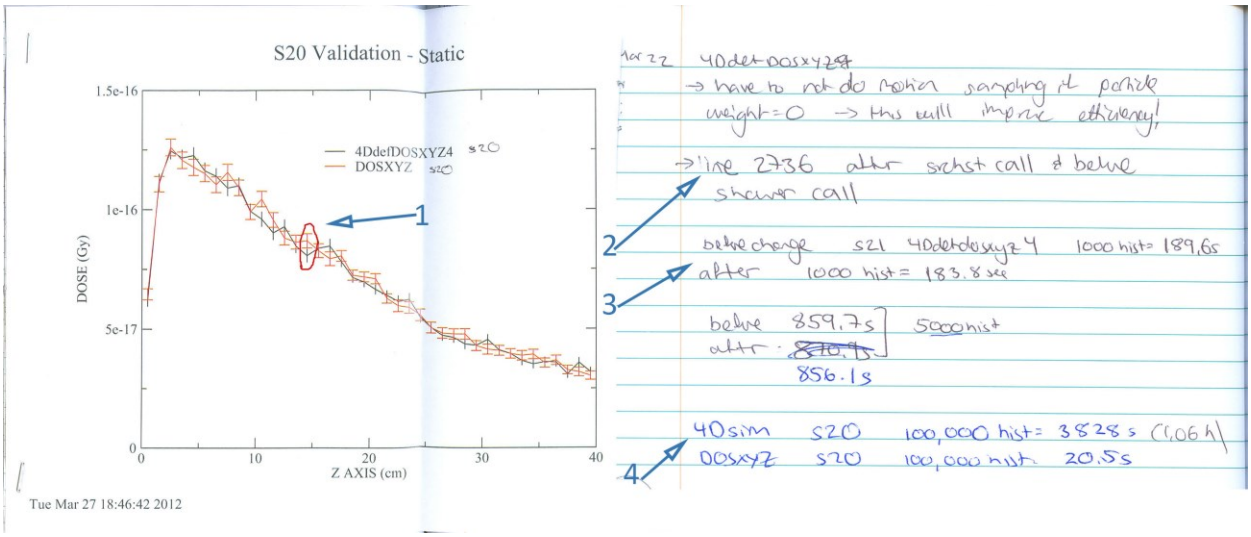


Figure 5.18. Excerpt about simulation code from Dr. Britney’s lab book. This figure shows a graph comparing a standard code with a modified version (left) and details about the results of the modified code (right) such as changes to specific lines of code (2), the time the it takes both codes to run (3), and time differences on a new operating system (4); a red circle identifies a variation in the code (1).

When I questioned Dr. Britney about whether or not the lab book entry would be readable and useable without either the graph or her notes, she explained that while it is helpful to be able to visualise the entire code with the graph, “it is not as informative as the detailed notes” (Br_MC_February2). This particular entry of Dr. Britney’s is modally complex even though she would have been able to draw on and recreate or modify the code without the graph. This is a key difference from the modal intensity present in Dr. Britney’s (see Figure 5.15) and Sean’s (5.14) modally intense entries. While still multimodal, the lab book entries would not have been readable or useable without the high intensity modes, whereas in the case presented in Figure 5.18, Dr. Britney would have been able to use the entry without the visual mode. Even though the graph may not be *necessary* to interpret the text on the accompanying page, I would still argue that this

lab book entry is modally complex because the graph adds information that Dr. Britney finds useful (Br_MC_February2).

Modal complexity is also present in Professor Poole’s electronic lab book. In fact, the electronic lab book is particularly interesting multimodally because different “entries”, or files, in the lab book are often combined in order for the lab book to be useful. Let me illustrate this with an example. Professor Poole expressed how when he and his students collaborate on a paper, he encourages them to begin by going into their lab book (or the electronic equivalent of their lab book) and starting from the graphs, figures, and tables that may have been generated during the experimental study (P_INT1_August19). However, when I asked Professor Poole whether or not he would be able to read the graph and use it in his writing up, independent of other notes, he explained that he needed to read the graph in the context of the other notes, both written and numerical, included in the electronic lab book (P_MC_December18). Figure 5.19, for instance, presents one of the graphs and its accompanying listing file in the electronic lab book. For Professor Poole to be able to use the graph, it needs to be read in combination with numerical and written modes, which detail notes about the experiment and the raw data output. This, therefore, is a case where the modal complexity relies equally on both visual and numerical modes in order for them to accomplish one of the purposes of the genre, that is, writing up results into a journal article.

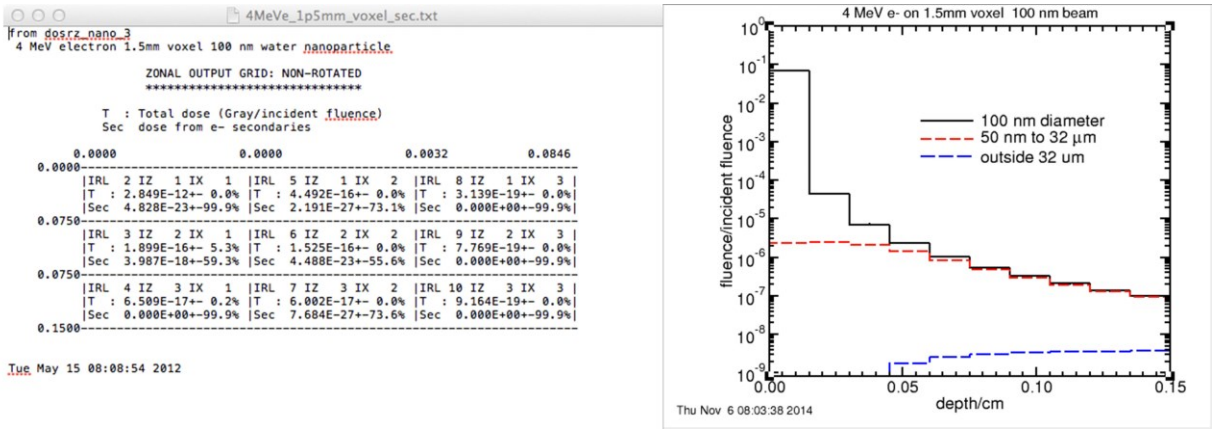


Figure 5.19. Excerpts from Professor Poole’s electronic lab book. The figure shows the numerical output (left) visualised in a graph (right).

In both cases presented in Figure 5.18 and 5.19, though, it is important to point out that the graphs do not create sufficient meaning on their own. Although both graphs may have begun as independent modes, they lose their independence when they are combined with the notes and raw data in both the paper and electronic lab book. This loss of independence is significant because it demonstrates how different modes may combine in order for the lab book to be useable. The combination of different modes is necessary to complete the higher-level, rhetorical actions of record-keeping and research facilitation.

Modal density. The final stage of the multimodal analysis determines how both the modal intensity and modal complexity of the lab books contribute to the lab book being used to accomplish higher-level (rhetorical) actions within the medical physics CoP, which Norris (2004a) refers to as modal density. In other words, the final stage of my analysis examines how modal intensity and complexity fulfill the purposes of facilitating research, facilitating writing, and facilitating teaching and learning.

Sketches are an important visual mode, and as such they are included in almost all of the lab books, the exception being the electronic lab book. As previously discussed, the visual modes in the lab books tend to have high intensity, making them integral to the higher-level action of knowledge creation and mobilisation. If a high intensity mode is omitted from an interaction, the high-level action of knowledge construction will be much more difficult to perform. In this case, the higher-level action of the lab book as a research heuristic would be very difficult to achieve. In many of the lab book entries, sketches carry the highest modal intensity. For instance, Sean explained that he tends to draw diagrams of geometries or figures in the lab book to help him find solutions to his research problems. In addition to Sean, Professor Burke also discussed the importance of sketches in the lab book. He explained that when he attempts an experiment, he sketches the parameters of the experiment (e.g., x-rays, objects, distances) in his lab book. One example comes from Sean’s lab book (see Figure 5.16). This entry is an example of the “puzzling out” stage of Sean’s research where he is using geometry to determine how to locate where a PeTrack marker is in real-time. The sketch in the centre of the page that depicts three points plotted on a circle was, according to Sean, instrumental to his ability to track the marker in real-time and correct for computer time delays (see Figure 5.16). Without the sketches of the angles Sean needed to calculate, deducing the correct angles would have been much more difficult. In this entry, the modal intensity of the visual mode contributed to Sean’s ability to solve the problem related to his research. The importance of the sketches links back to the purpose of the lab book as a facilitating genre in medical physics research: by sketching in the lab books, the participants are

better able to plan experiments, derive solutions to research problems they may be encountering, and keep track of past experimental configurations.

Like sketches, graphs are also an important visual mode in the lab books. Unlike sketches, however, graphs do not tend to take on a high modal intensity. Instead, graphs are typically modally complex, as was demonstrated in Dr. Britney's and Professor Poole's lab books. In Dr. Britney's entry (see Figure 5.18), the lab book is being used as a heuristic to develop and plan research. Interestingly, in Professor Poole's discussion about graphs in the lab book, he explained how the graphs are often used in the process of writing up a new journal article or conference paper, in addition to helping students learn about how to approach writing these visible knowledge-making genres (P_INT1_August19). Of course, the modal complexity of lab book entries also plays a role in the modal density of the lab book. For example, when medical physicists write research objectives and plans in their lab books along with schematic drawings and filenames, the modal complexity of the ensuing entry could be said to have high modal density. This is because the higher-level rhetorical action of planning and facilitating research is at the forefront of the researcher's mind when creating the entry, that is, one of the purposes of the genre is foregrounded. The lab book entry, therefore, has high modal density because the producer of the text is acting upon an exigency (needing records to facilitate research) and is *consciously aware* of using the lab book to fulfill this exigency. As previously discussed, high modal density draws attention to the higher-level actions that are being performed in a specific context. I would argue that in the context of medical physics labs, the lab books tend to carry high modal density; that is, when the participants use their lab books they tend to be aware of the higher-level actions they are

using the lab book to achieve. For instance, when I asked Dr. Britney about the purpose of the lab book entry detailing the modified DOSXYZ code (see Figure 5.18), she was very aware of why she was recording specific data in her lab book and, furthermore, how she might use these data in the future. Thus, Dr. Britney has an acute awareness of the higher-level action being performed by the lab book when she brings it into her activity.

The findings and analysis presented in this chapter have shown how the lab book is implicated in a variety of activity within the CRU CoP. For instance, the lab book serves as a key mediating artefact in facilitating research, facilitating writing, and in identity construction and maintenance. The analysis of the modal intensity, complexity, and density has found that the multimodal nature of the lab book plays an important role in the genre’s ability to achieve higher-level rhetorical action. In the following chapter, I discuss these findings in light of the theoretical constructs presented in Chapter Two.

Chapter Six: Discussion of Findings

Before starting a discussion of the findings of this study, let me recapitulate my main research questions. The overall aim of this study is to explore how knowledge is discursively constructed in an academic medical physics lab. The emergent nature of this study led me to discover the key role lab books have in knowledge construction, leading to the following questions:

1. How does the genre of the medical physics lab book facilitate the knowledge-making work of the medical physics community?
2. How does the lab book facilitate discipline member's professional identity construction and maintenance?
3. How does the multimodal nature of the lab book facilitate both the knowledge-making work of the medical physics community and the identity construction and maintenance of its members?

In order to explore these questions, let me first return to the purposes that the genre fulfills. The distinct, but related, purposes of the lab book as a research heuristic, writing heuristic, and teaching and mentoring aid demonstrate the genre's role as a dynamic and central mediating artefact within the medical physics CoP. That is, the lab book is a key mediating instrument in most, if not all, of the knowledge-making work done within the medical physicists' CoP. In order to further explore how the lab book's role as a mediating artefact is implicated in the medical physics labs' knowledge-making work, I trace the genre's effect within the genre ecology of medical physics and examine how the multimodal nature of the lab book facilitates knowledge-making, teaching, and identity formation and maintenance.

Role of the Lab Book in the Medical Physics Genre Ecology

One of the most notable aspects of the lab book, besides its several different but equally important purposes, is its presence in the knowledge-making work of the medical physics CoP. While the lab book does play an important role in knowledge construction, it is what Swales (1996, 2009) calls an "occluded genre" (1996, p. 46). Swales describes these genres as either spoken or written genres that are created for "specific individual or small group audiences . . . may also be seriously invested with demonstrated scholarship . . . [and] are typically hidden, 'out of sight' or 'occluded' from the public gaze" (p. 46). Here, Swales describes how occluded genres, while often hidden from the public and intended for a very small and often personal audience, are nonetheless important to the activities going on within a particular community. Swales uses the example of submission letters, which accompany articles sent to journals to be considered for publication, to demonstrate how although the journal article will eventually be more visible and widely disseminated, the submission letter is still a part of the submission process.

In the genre ecology of medical physics, I would argue that the lab book is an occluded genre: it is written most commonly for an individual or small audience, is all but invisible to outsiders to the community, and nonetheless plays a very important role in the knowledge-making work within the discipline. The lab book is a ubiquitous genre in this CoP because it mediates most, if not all, of the knowledge-making activities in the medical physics labs. All of my participants had a record keeping device, be it paper or electronic, which allowed them to facilitate both their research and writing of more visible genres. That is, although the lab book is not commonly viewed as a prestigious

knowledge-making genre like academic journal articles or conference papers tend to be, genres like the journal article grow out of the lab book. This is because the genre of the lab book serves as a facilitative heuristic for both research and writing up research results. The lab book's role within the activity (cf. Engeström, 1987) of the genre ecology (Spinuzzi & Zachry, 2000) is shown in Figure 6.20.

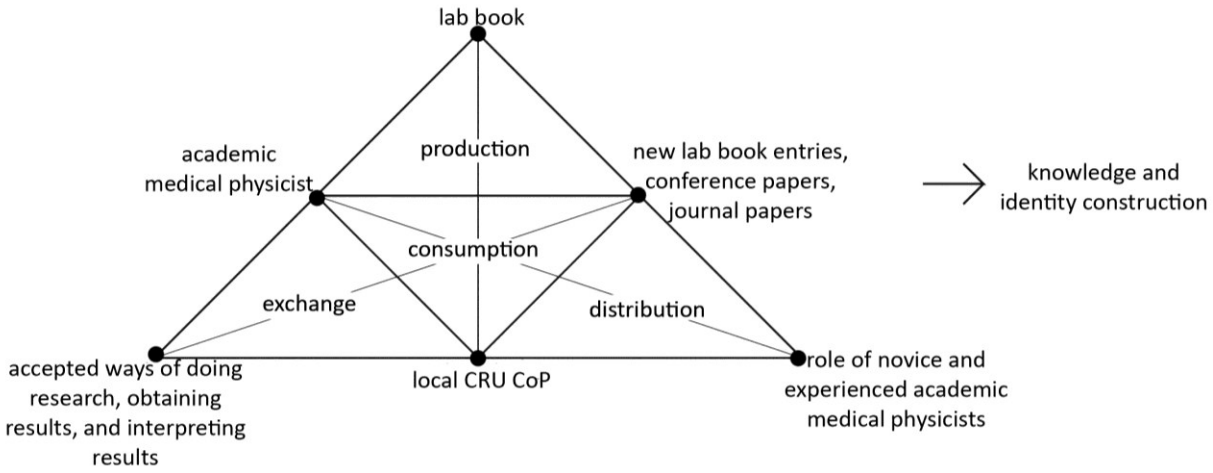


Figure 6.20. The CRU's medical physics AS. This figure shows an AS depicting the role of the lab book in knowledge and identity construction, in addition to its connection with other genres in the genre ecology (e.g., conference papers and journal articles).

Despite the lab book's lack of prestige, it still works in conjunction with other genres in order to mediate activity, a feature that is central to the notion of genre ecology (Spinuzzi & Zachry, 2000). In the genre ecology of medical physics, the lab book shares connections with numerous other genres, such as conference abstracts, journal articles, dissertations, all of which collectively coordinate the activity of medical physics knowledge creation. As a research heuristic, the lab book is an important repository of research planning, procedure, and results, all of which are important in the knowledge-making practices within the discipline. Without lab book entries detailing the various

stages of the research carried out in professional medical physics labs, it would be difficult, if not impossible, to accurately report on the results of the research. So while it may not be "visible" outside of the medical physics community, it occupies a fundamental space in the genre ecology.

The Lab Book as a Means of Participation and Reification

Here, I argue that the medical physics lab book functions as a dynamic mediating artefact in the genre ecology of the medical physics labs at CRU. The lab book has a particularly important function enabling members of the CoP to participate within the community, while at the same time allowing the members to reify the community and its ways of knowing and doing (Wenger, 1998). A second important argument that I make in this chapter is that the lab book is able to function as a means of rhetorical action *through* its multimodal nature. By this, I mean that the multimodality of the lab book is important not only in the knowledge-making activity of the participants in this study, but also in the activity of identity construction and maintenance. Before going into more detail about the role of multimodality in the lab book, I discuss how the genre's role in the genre ecology of the medical physics labs facilitates the participation and reification of the CoP and its members.

Participation and identity construction and maintenance in the CoP. As I mentioned in the beginning of this thesis, my study has an emergent design. This is important to note here because at the outset of this research project, I was not expecting to find the lab book to be a genre that was closely bound to the professional identities of my participants; however, my coding of interview data revealed that the lab book is actually an important genre in both the development and maintenance of professional

identity in medical physics. In fact, my findings have led me to argue that the lab book is a central mediating artefact not only in knowledge construction, but in identity construction as well.

As I discussed above, the lab book serves as a mediating artefact in teaching and learning in the discipline of medical physics. It became evident based on my coding “template” that these two notions, teaching and learning, are very closely connected with my participants’ professional identities in their labs. It also became clear that one of the ways in which these identities are both constructed and maintained was through the lab book as a mediating artefact. In other words, keeping a lab book, be it paper or electronic, serves as a means of participating in the medical physics CoP. The lab book serves as an important genre allowing the members of the CoP to participate within the CoP and, consequently, develop their identities within it (Wenger, 1998). Let me illustrate how this happens with three of my participants who have varying degrees of experience within the field: Sean, Dr. Britney, and Professor Poole.

Based on my findings, I would argue that for Sean, the most novice participant in this study, the lab book functions as a mediating artefact that both enables him to learn the ways of knowing and doing in medical physics and develop his professional identity within the field. As I have discussed, a great deal of Sean’s work is computational, meaning most of his work with PeTracking devices is simulated on computers before they are tested on patient phantoms (simulated humans) in clinic scanners and on live patients. To keep track of past simulation and experimental results, Sean records the information about the research in his lab book, along with the accompanying file names and results. By doing this, Sean is participating in the CoP’s ways of knowing and doing.

The act of conducting the experiment alludes to the many inherent practices that Sean has internalised as he has learned in and about the field: the kind of knowledge it values and the ways it goes about constructing this knowledge.

I also wish to point out the importance of multimodality in the participation and identity construction of the participants in this study. In Chapter Four, I discussed the notion of modal density, the awareness that individuals have of the higher-level actions (in this case the rhetorical actions) that they are accomplishing with a multimodal interaction or text. Modal intensity and modal complexity both combine in order to achieve modal density (Norris, 2004a) and, in this study, my analysis of the multimodal lab book entries demonstrated how several different modes are used in order for the lab books to construct knowledge and identity. Lower-level actions are the various modes present in a lab book entry (e.g., sketches, mathematical notation, and writing), and the higher-level action is how the entry is used by or brought into the actions of a medical physicist researcher. Another example could be the actions that lab books are involved with. In this case, the lower-level action of inscribing entries into the lab book makes up the higher-level action of, for instance, recording experimental results in the lab book. I should also point out that while participants may not be consciously aware that they are maintaining and constructing identity when they use their lab books, I would still consider this to be a higher-level action. As Schryer (2002) writes, individuals genre their identities when they learn to produce and subsequently produce community-specific genres. Thus, in this study, I view the ways of knowing and doing in the academic medical physics CoP as being embedded in its genres. Therefore, in the same way that knowledge-making is higher-level action, so too is identity construction.

Again, based on my analysis and findings that are presented above, the lab book produces knowledge and identities within the CRU medical physics CoP. It is important to note that this construction is facilitated through the multimodal nature of the lab books, both electronic and paper. Despite the difference in materials between the two lab books, the meaning-making and identity-constructing product remains the same. In this case, the lab book retains its rhetorical functions despite the changes in the medium.

The lab book’s role as a mediating artefact enabling participation within the field has another function that, again, aids in constructing Sean’s professional identity. The lab book in this discipline functions in a similar way to the architectural notebook used by students in a study by Medway (2002). Medway discusses how architecture students’ notebooks, while not a site of direct participation with other members of the architectural community, function as a rhetorical space in which they can develop a self that will be capable of participating in the architectural community. I would argue that, for Sean, the lab book serves a similar function. The occluded nature of the lab book provides a rhetorical site for Sean to develop the accepted ways of knowing and doing in the field, while still participating in its knowledge-making activities. The lab book acts as a way of learning the field and developing his identity as a medical physicist, which includes the practice of keeping a lab book.

For Dr. Britney and Professor Poole, however, the lab book functions slightly differently. Although I would claim that the lab book still functions as a means of participation in the local activities of the medical physics unit at the CRU for Dr. Britney and Professor Poole, the overall object of the activity is not entirely the same. For Dr. Britney and Professor Poole, the lab book functions as a means of maintaining their

professional identities as academic medical physicists and as mentors to novice medical physicists (i.e., graduate students). Both Professor Poole and Dr. Britney explained to me that they ensure all of their graduate students use a lab book when they are conducting their research, whether the lab book is a bound paper notebook or a collection of files on a computer. Professor Poole also told me that he sometimes checks his students "entries", which tend to be Excel files and graph files due to the nature of his research.

The lab book in the academic medical physicists' case functions similarly to the lab report in Carter, Ferzli, & Wiebe's (2007) investigation into the practices of novice biologists. In their study, the lab report functioned as an "apprenticeship genre" (p. 294) that enabled students to learn about the accepted ways of creating and communicating research findings. While I would not go so far to say that the lab book is an apprenticeship genre (I believe that since the genre is used by professional academic physicists as well as novices, the genre is professional), I would argue that the lab book functions similarly to the lab report in a very key aspect: it creates a rhetorical space for mentors to teach their students about the practices of the local laboratory CoP, as well as the global CoP of medical physics. Of course, participation is only one part in a duality of how CoPs are constructed and maintained; members must not only participate within, but also reify the CoP.

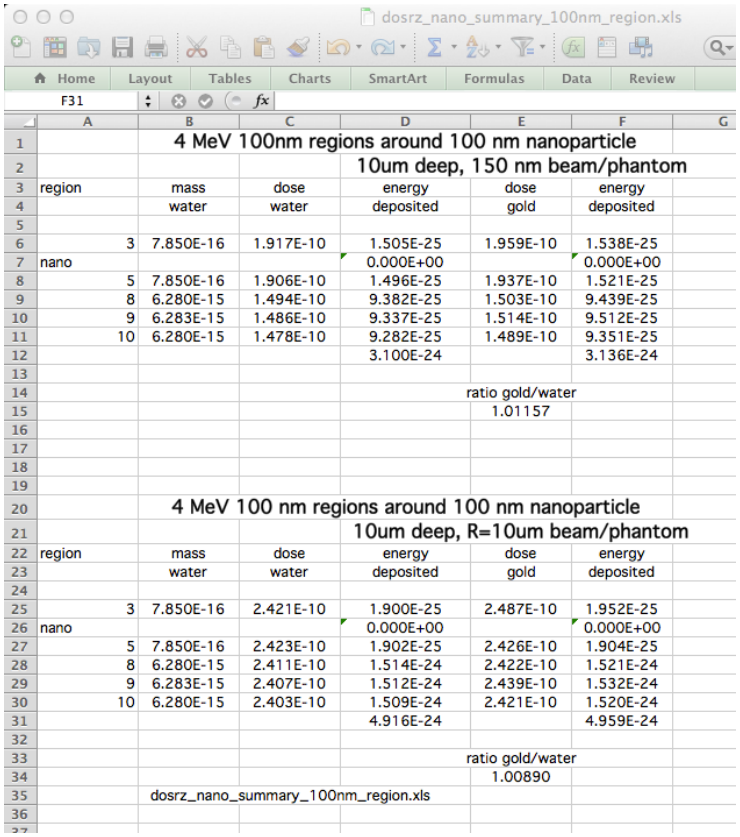
Reification and knowledge construction in the CoP. RGS views genres as having a dialectical relationship with the CoPs wherein they are found. That is, genres not only reflect the ways of doing and knowing of particular communities, they also play a role in constituting, or reifying, those communities. In medical physics, I would argue that this is evident through examining the genre of the lab book. The lab book's

importance extends beyond the knowledge-making practices of the discipline. The medical physics lab book, for instance, could be viewed as the reification of not only abstract thoughts and concepts that are concretised in the material lab book, but also to make tangible in a written record activities and experiments that are carried out by the keepers of the lab book. Let me use Sean as an example to illustrate this.

As I discussed above, the lab book provides a space for Sean to participate within his local CoP at CRU and develop his professional identity. At the same time, Sean is also reifying the CoP. As Wenger (1998) writes, participation and reification constitute "an interacting duality" (p. 67), meaning that the two elements always interact with each other. In this case, through the act of inscribing information about his research into his lab book Sean reifies not only his work, but his discipline as well. That is, by inscribing results into his lab book, Sean is concretising, or reifying, what is otherwise an ephemeral object. These ephemeral objects may include simulations, virtual and non-virtual past experiments, and methods used to create simulations. Regardless of what the object is, it exists as a "real" entity only as it is reified through being recorded in the lab book. While the simulations and experiments Sean runs are arguably already concrete entities, it is the action of inscribing information into the lab book that makes the *results* real and useable.

Interestingly, just like Sean, Dr. Britney and Professor Poole use their lab book to reify their experimental results. Like Sean's, most of Dr. Britney's and Professor Poole's research is computational and involves them running simulations of radiation treatments or devising dosimetry measurements (see Glossary). I would argue that in their cases as well, the lab book serves as a means of reifying both the knowledge work that they do and the ways in which they do this work. For example, in Professor Poole's electronic lab

book he has several Excel and text files in the folder marked “data_summary” (see Figure 4.5) that records the results of his simulations. Figure 6.21 presents an example of an Excel sheet from this folder that records a data summary of several simulations. This particular record serves as a means of reifying the findings of the simulations and makes the lab book “warranted as knowledge . . . through the convergence of technical procedures and textual documentation practices”, that is, turns it into an epistemic object (Wickman, 2010, p. 291). Reifying the technical and experimental aspects of the study into a textual form, the lab book reifies the knowledge created during the experimental process by enabling it to be drawn upon again in the future.



dosrz_nano_summary_100nm_region.xls

		4 MeV 100nm regions around 100 nm nanoparticle				
				10um deep, 150 nm beam/phantom		
region		mass	dose	energy	dose	energy
		water	water	deposited	gold	deposited
	3	7.850E-16	1.917E-10	1.505E-25	1.959E-10	1.538E-25
nano				0.000E+00		0.000E+00
	5	7.850E-16	1.906E-10	1.496E-25	1.937E-10	1.521E-25
	8	6.280E-15	1.494E-10	9.382E-25	1.503E-10	9.439E-25
	9	6.283E-15	1.486E-10	9.337E-25	1.514E-10	9.512E-25
	10	6.280E-15	1.478E-10	9.282E-25	1.489E-10	9.351E-25
				3.100E-24		3.136E-24
					ratio gold/water	
					1.01157	
		4 MeV 100 nm regions around 100 nm nanoparticle				
				10um deep, R=10um beam/phantom		
region		mass	dose	energy	dose	energy
		water	water	deposited	gold	deposited
	3	7.850E-16	2.421E-10	1.900E-25	2.487E-10	1.952E-25
nano				0.000E+00		0.000E+00
	5	7.850E-16	2.423E-10	1.902E-25	2.426E-10	1.904E-25
	8	6.280E-15	2.411E-10	1.514E-24	2.422E-10	1.521E-24
	9	6.283E-15	2.407E-10	1.512E-24	2.439E-10	1.532E-24
	10	6.280E-15	2.403E-10	1.509E-24	2.421E-10	1.520E-24
				4.916E-24		4.959E-24
					ratio gold/water	
					1.00890	
		dosrz_nano_summary_100nm_region.xls				

Figure 6.21. Results summary table file. A file from Professor Poole’s electronic lab book demonstrating how data generated by a simulation are reified into a multimodal record.

Furthermore, the inscriptions in lab book entries tend to be multimodal. That is, most lab book entries make use of several modes in order to facilitate the higher-level actions, or rhetorical purposes, that the lab book accomplishes. For instance, in a lab book the addition of a visual mode (e.g., sketch) is likely to enable the rhetorical action of the lab book (e.g., facilitating research). But the omission of that same visual mode from the lab book would constrain the lab book’s user from performing a rhetorical action. As shown in my analysis (see Chapter Five), the lab book’s multimodal nature is crucial to the lab book being able to be read and used by the professional academic medical physicists. That is, the multimodal elements of the lab book serve to reify otherwise

abstract objects for use within the work of the local laboratory CoP and the global academic medical physics CoP. Let me use Professor Poole as an example to illustrate this. In his electronic lab book, Professor Poole has several kinds of data files that often need to be read together in order to make meaning (i.e., the numerical listing file and the graphed results). The record of the listing file and its subsequent transformation into a readable graph facilitates Professor Poole’s research in his local laboratory CoP and reifies the simulation into a set of results. When these results are written up into drafts and finally submitted as a journal letter, the multimodality of the initial knowledge-making product ensures that the reified results can be shared amongst the wider medical physics CoP. Without the combination of modes within each lab book, the knowledge-making work of the participants would be next to impossible.

Professor Poole’s use of an electronic lab book is especially interesting because it echoes how genres respond to changes in communities where they are deployed (e.g., Bazerman, 1988). Like the physics article evolved in response to the changing nature of the community, it appears that the lab book is also evolving in response to the increased technological nature of Professor Poole’s research. Indeed, while Professor Poole initially claimed that he had stopped keeping lab books, upon further reflection he conceded that Excel spreadsheets and text files with notes about a project have “in some senses . . . replaced lab books” and that in a sense his “notebooks are in the computer these days rather than in a physical notebook the way it used to be” (P_INT1_August19) (cf. Artemeva & Fox, 2011). Even Sean, while he does keep a paper lab book, admitted during our second member check interview that he has started keeping an increasing amount of notes and data electronically rather than written in the notebook

(S_MC_December11). Like Professor Poole, Sean's research is primarily computational and he spends a great deal of time running simulations. Thus, the changes that the genre of the lab book seem to be undergoing could be directly connected to the rapidly evolving technology used in medical physics research.

I should point out though that genres do not always harmoniously evolve in tandem with particular communities (Schryer, 1994). That is, tensions may exist between the practices of the community and the way in which genres respond to these practices. This is also a concern that third generation AT attempts to address (e.g., Spinuzzi, 2003). In this study, while some of the lab books do seem to be evolving along with the technologisation of the field, some participants did articulate the tension between the technological nature of medical physics research and the integral mediating artefact used during the research process. When Dr. Britney was explaining how she drew on her lab book during the research process, she described the tension of the current form of the lab book and the nature of her research:

> I don't feel like the way of keeping the lab book is [optimal] right now . . . because the issue I have with the paper lab book is it can be very hard to find [information]. Everything is dated, but if you can't remember . . . what date you did something, [you have] to go through page by page [looking]. Sometimes putting sticky notes for different topics and locations, but that always feels very messy too. I have a colleague who keeps everything on a computer file so that he can search it. But it's just one *massive* file for the whole year . . . Some people keep online notebooks as well because they can search them, but . . . I'm always a little bit distrustful of keeping important things like that on the computer because

> I’ve always experienced computer crashes and lost stuff, so. In the end you can always rely on what you wrote down in your lab book. [It’s] searchability and indexing [that] is a bit frustrating right now. (Br_INT1_July9)

Here, Dr. Britney is describing the tension she feels between her lab book’s capabilities and the nature of her research. In Engeström’s (1987) version of AT, a secondary contradiction between two nodes of an activity system is considered. Secondary contradictions are, as Spinuzzi (2003) writes, quite common in evolving activity systems. Since the activity of the medical physics labs I investigated was largely computational, tensions seem to have developed between Dr. Britney’s research and her lab book’s ability to facilitate this research. This tension could, in the future, lead Dr. Britney to find an innovative way of using the lab book to resolve the contradiction between her work and the mediating artefact she uses to facilitate this work.

Here, I want to return to the multimodal nature of the lab book as a means of participation and reification of the medical physics CoP and its members. That is, it is at this point necessary to ask what this indicates about knowledge-making practices in CRU’s academic medical physics labs. When the medical physicists in this study inscribe entries in their lab books, they reify the accepted ways of knowing and doing in the discipline. The lab book inscriptions are, in this case, epistemic. By this, I mean that the lab books serve to warrant claims that physicists “make with respect to the objects and processes they have created” (Wickman, 2013, p. 152). The fact that the lab book functions as an epistemic object that enables further knowledge-making activity is especially important because, as I mentioned, the participants’ work is largely simulation based. The simulations produced in the CRU’s medical physics lab, whether they

represent radiotherapy patient histories or advances in imaging techniques, are ephemeral objects of study. The transience of the simulation functions as a “type of deliberative space within which scientists can project meaning that has yet to be realized in any material sense” (Wickman, 2015, p. 67). That is, the simulations are used to recreate phenomena that have the potential to exist outside of the computer and must be “argued into existence” (p. 67). Medway (1996) also discusses how verbal and symbolic activity (i.e., writing) is “productive work that further realizes, pins-down, and brings into the zone of the confirmed, shared reality a *something* [emphasis added]” (p. 501). That is, the lab books’ multimodal inscriptions provide a means of transforming ephemeral objects of study, like the simulations, into a shared epistemic resource. The record of the experiment in the lab book serves to reify the simulation itself and the claims that will be drawn from that record.

Basically, the lab book enables participation and reifies knowledge created. By reifying knowledge in the lab book, the participants open themselves up to being able to draw on the genre in order to produce other publications. Additionally, by participating in the reification of abstract knowledge in the lab book, participants are reproducing the accepted ways of doing research within the CoP, and thus the accepted ways of creating new knowledge within the CoP. After all, the lab book leads to publications that will eventually be distributed across the wider medical physics community. This reification will, in turn, be transformed into knowledge to be disseminated across this larger medical physics CoP. The lab book inscriptions make *real* the knowledge-making work that the physicists have developed and tested through their research. It is in this way that my

participants both participate in and reify their work using the lab book as a mediating artefact to make real objects of study that otherwise would not exist.

Chapter Seven: Conclusion

The aim of this study was to explore the knowledge-making practices of an academic medical physics community, particularly how multimodality implicates and affects the knowledge-making work that goes on in medical physics. The emergent design of this thesis led me to focus on questions related to how the medical physics lab book serves as an important genre in the knowledge construction practices within the community, how the lab book plays a role in the identity construction and maintenance of members of the discipline, and how the multimodal nature of the lab book facilitates its role within medical physics. Using a combined theoretical and analytical framework of Writing, Activity, and Genre Research (WAGR), communities of practice, and multimodality, I examined how the lab book functions as a central, but occluded (Swales, 1996), knowledge-making genre within the field. Analysis of interview data with professional academic medical physicists and an advanced doctoral student in the discipline as well as of their multimodal lab book entries revealed that the lab book serves an important role as a mediating artefact in knowledge-construction and identity construction and maintenance.

As I discussed above, in the CRU's medical physics genre ecology the lab book is deployed to suit a variety of purposes within the lab because the genre itself is so dynamic. That is, the genre of the lab book has established relatively stable connections with a variety of other prominent epistemic genre in order to accomplish particular activities within the community, including facilitating research, facilitating the writing up of research findings, and facilitating the teaching and learning of novice members of the community. The position of the lab book within the genre ecology speaks to its vital role

in the goals of the community: in order to participate within the community and learn its ways of knowing and doing, novices must learn to keep a lab book (B_INT1_July9); in order to participate in the research practices of the discipline, academic medical physicists keep a lab book to enable the production of notes; and, in order to concretise the results developed from research, the lab book acts as a means of reifying abstract and ephemeral objects like computer simulations. I also found the lab book to be an epistemic object (Wickman, 2010) that constitutes a “durable textual resource” (Medway, 1996, p. 285). That is, the lab book is a multimodal and rhetorical site that allows for its users to develop and negotiate their identities within the medical physics CoP and provides them with a means to reify results that must be written into existence outside of a simulation.

In addition, while the lab book does serve as an important mediating artefact in the knowledge-making work of medical physics, there appear to be some tensions that are arising between the lab book and its purpose. That is, the evolving nature of the discipline of medical physics seems, in some cases, to necessitate the evolution of the lab book as a genre, as was the case with Professor Poole and Sean, while Dr. Britney seems to experience tension between the mediating artefact and its role within the activity system.

Limitations, Significance, and Implications of the Study

While I have attempted to address questions related to knowledge and identity construction in the discipline of medical physics, I realise that this particular thesis only scratches the surface of the practices of a very complex community. As such, it is important to outline the limitations of this study.

First, the study draws on data from a small sample size of only five participants. While this sample size did allow for an in-depth analysis of the lab book and how each

individual uses the lab book, the small sample size does not allow for generalisations to the wider scientific, or even medical physics community. A larger sample size would have provided the means of drawing more generalizable conclusions. Second, the scope of this thesis limited the amount of analysis that could be reported on. That is, while a thorough rhetorical and multimodal analysis of the lab books was conducted, the scope of the thesis limited the findings that could be reported. Third, observations of all participants would have been ideal; however, due to the nature of some of the participants’ research (e.g., hospital research), I was not able to receive ethics clearance to observe participants in a hospital setting.

Despite its limitations, I do believe that this study contributes to both knowledge of discursive knowledge construction in the natural sciences and to the field of writing studies. For instance, this study contributes to the small, but growing, number of studies exploring “hidden”, or occluded science genres, specifically the lab book (Wickman, 2010, 2013). This provides more insight not only into the culture of science and scientific knowledge-making practices, but also into the ways in which new students learn about the discipline. In addition, the suggested importance of the lab book in all forms (i.e., paper *or* electronic) could contribute to knowledge of evolving activity systems in academic medical physics. Future avenues of research could include examining lab books in a variety of medical physics labs and tracing how knowledge that begins in the lab book is written up in other more visible genres, distributed, and subsequently consumed by the wider medical physics community. In addition, further investigations into the secondary contradictions in the AS may lead to insights into how the genre of the lab book may be evolving in order to respond to changes within the AS.

In addition, this research contributes to the small, but again, growing approach of combining RGS with socially-oriented approaches to multimodal analysis (e.g., Artemeva & Fox, 2011; Fox & Artemeva, 2012). In a society wherein multimodality seems to be playing a more overt role, it has been suggested that RGS scholars should be exploring ways of better analysing the multimodal genres that are becoming commonplace (Bawarshi & Reiff, 2010). My hope is that my attempt at integrating a socially-oriented approach to multimodal analysis (Norris, 2004a) with textual genre analysis will serve as a stepping stone to be improved upon in future multimodal RGS analyses.

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Appendix A

Ethics Clearance

Carleton UNIVERSITY
Canada's Capital University

Carleton University Research Office
Research Ethics Board
1325 Dunton Tower
1125 Colonel By Drive
Ottawa, ON K1S 5B6 Canada
Tel: 613-520-2517
ethics@carleton.ca

Ethics Clearance Form – New Clearance

This is to certify that the Carleton University Research Ethics Board has examined the application for ethical clearance. The REB found the research project to meet appropriate ethical standards as outlined in the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Human, 2nd edition*, and the *Carleton University Policies and Procedures for the Ethical Conduct of Research*.

Date of Clearance: June 05, 2014
Researcher: Sara Doody (Student Research: Master's Student)
Department: Faculty of Arts and Social Sciences\Linguistics and Applied Language Studies (School of)
University: Carleton University
Research Supervisor (if applicable): Prof. Natalia Artemeva
Project Number: 101559
Alternate File Number (if applicable):
Project Title: Writing and Visualising Medical Physics: The Role of Multimodality in Knowledge Construction (Working Title)

Clearance Expires: May 31, 2015

All researchers are governed by the following conditions:

Annual Status Report: You are required to submit an Annual Status Report to either renew clearance or close the file. Failure to submit the Annual Status Report will result in the immediate suspension of the project. Funded projects will have accounts suspended until the report is submitted and approved.

Changes to the project: Any changes to the project must be submitted to the Carleton University Research Ethics Board for approval. All changes must be approved prior to the continuance of the research.

Adverse events: Should a participant suffer adversely from their participation in the project you are required to report the matter to the Carleton University Research Ethics Board. You must submit a written record of the event and indicate what steps you have taken to resolve the situation.

Suspension or termination of clearance: Failure to conduct the research in accordance with the principles of the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, 2nd edition and the Carleton University Policies and Procedures for the Ethical Conduct of Research may result in the suspension or termination of the research project.

Andy Adler
Chair, Carleton University Research Ethics Board

Louise Heslop
Vice-Chair, Carleton University Research Ethics Board

Appendix B

Sample Interview Questions

1. Please tell me about your research.
2. Do you use any writing in the lab (e.g., notes, manuals, articles)?
3. Are there any materials (e.g., manuals, documents) you use to prepare an experiment? Are there any materials you use in general academic work?
4. If you were to read a new manual or journal article, what do you pay attention to? Do you read certain parts of the text first?
5. How do you start writing a journal article? What resources do you draw on?
6. When you produce writing, for a logbook, for journal articles, etc., what role do visual elements (e.g., mathematical notation, charts) have on your composing?
7. Who do you envision reading the texts that you produce? Does this effect how you write at all? Does it affect the kinds of visuals you use?

Appendix C

Sample Interview Transcription and Text Used for Interrater Reliability Rating

At this point in the interview, Professor Poole (P) had been telling me (S) about how he tended to read published journal articles. He, and the other participants, all stressed the importance of the graphs, charts, and figures to being able to read and comprehend the claims being presented in the article. Prior to this, Professor Poole was explaining his own research and how it should (ideally) be presented in journal articles. Here, I ask him about this, as well as for specific examples of how non-text is integral to the comprehension of knowledge claims in his field.

Distinct units of analysis are separated and numbered.

S: It's interesting because pretty much everybody I've talked to said the same thing. The abstract and conclusion is something you'll actually read, but then it's mostly, look at the figures, look at graphs, look at the equations, if there are any images, look at those, and *that's* really where you get the gist of-

P: The paper.

S: Of what's going on.

P: Yes. And where you pick up…

As I say, if you end up working very specifically on the same problem, you'll read it in more

detail because you need to pull out the information.

But, I just don't have time to read all the things I find interesting. I just want to know, keep

abreast of what's going on in case it tangentially affects something I've been working on.

S: Right. So you mentioned numbering equations, and I was wondering about equations in particular because I've head a lot of people talk about charts and graphs and image, but I'm curious about equations. I guess, would they be important or, how would they be important of getting the main point of the article?

P: Well just, I guess because it's such a succinct way of actually stating something, ok? So you, the other thing you have to do is make sure that every piece of notation in an equation is

defined so that the reader knows what's going on, and it's amazing how often that *isn't* done. As

a referee, one of my most common comments is what does k mean in this equation. Frequently it

should be obvious

but it's really critical that it be very explicit in science because, otherwise, five years from now

or ten years from now, someone will look at it and other things have changed. So now, k doesn't mean what it meant. In 1990 it may have meant something but now it's being used in another context by almost everybody fifteen years later, so you should have said exactly what you meant by your notation at the time.

So, yeah, and as I say, it's just a very precise way of showing relationships and defining what

you mean.

Now, it's important to have simple and clear equations.

This last paper that I've been involved with, we had a huge battle with the editor and referees

because we found that, it turned out an important the editor had been part of writing five years ago, he had got things mixed up, and his own notation was so complicated you couldn't… you couldn't understand it, in my opinion.

We were clarifying, first of all, that it was wrong. Second of all, well, we didn't say it was- well,

we said it was wrong, we didn't say it was too complicated to understand (laughs), that wouldn't have been nice. But we had to point out it was wrong because it was directly contrary to what we were saying in our paper, or the way we were using the notation, it was wrong because he didn't refer to the definitions.

But that's the point. Equations are really the succinct way of coming up with things, in physics

especially, that's the way we all think.

Some papers have a lot more equations in them than others. I mean, I've written some papers

with two or three equations in them and other papers will have twenty or thirty, just depending on whether we're deriving something or making use of equations other people have developed in the past.

But it's the succinctness that makes them reliable.

S: Okay. Let me just check my list here.

P: Okay.

S: Um, well this is kind of related to what we've been talking about, in terms of writing journal articles. If you were writing a journal article or some other kind of document, I was wondering where you would start. Are there any documents you would draw on… I know you said you don't keep a lab book, but is there anywhere you keep track of past experiments, from other people's work?

P: It's hard to say. Because our work is computational, you hope that you have a set of results

that make some sense, that you want to clarify or publish so people can make use of it. And again, in one of those documents, I think it was the PowerPoint or the PDF that I sent you, quite literally some people writing a paper will start with the conclusions because you should know what you want, that's the take away message, basically, what you want people to-

I always write the abstract last but the conclusions, I don't usually write the conclusions first, but

I've got the conclusions that I'm heading for in my mind and that's very clear to me. So frequently, you know,

and with students, because I must admit the majority of papers, in quotes, *I* write these days,

students write together with me. I will ask them to lay out the structure, so just give me section headings that they're going to use and maybe one or two points, if it's not obvious, then one or two points in each section.

But then get all of the figures and all of the tables together. Basically, get all of your *results*

together into a document because that's what the paper's for, is to put your results out there. And make sure you know how you want to use those results for, to come to you conclusions, whatever they are.

Again, you don't want more information than is useful to the world.

I was just involved in refereeing this paper where they have eight more than one page tables in

this document, and the world doesn't want those eight pages of those numbers. They were just, they didn't need them to understand the paper and,

yes, I mean if they want other people in the world to have them they can put them up on the web

these days in a repository and people can get a hold of all those details.

But when you're reading the paper, you don't need the details. So you just have to be careful not

to have too many tables or it can give spurious results that aren't part of your conclusions or the line of logic to get to your conclusions.

And that's hard! At the beginning for students, we often have to iterate several times about that

point, and that's where, I mean again, because I've been in the field for some time now, I can help them know what people out there reading it will understand and take as a given because another problem most students have at the beginning is they've been so immersed in

their own project, they want to do a core dump of everything they've learned. But the rest of the world learned all of that stuff back in graduate school too, they want to know what you've done that's new and different, so we have to filter that way.

But, it's a constantly evolving, like this last paper that we were involved with, the first pass had,

we thought was okay, and then we gave it to a bunch of friends to read and some of them came back and said 'you've got this wrong' and 'I don't understand this' or whatever. And so we had to go back and we realised that even ourselves, we were a little confused about the way we were presenting the results,

so I ended up rewriting the introduction and putting in a whole, in that case I added fifteen

equations because we figured it was sufficiently confusing. We had sort of jumped to the conclusion people would know what we meant, and then we had, they clearly hadn't, so we had to go back and lay out the context, the formalism for the rest of what happened, so you have to constantly get feedback from people to see what's going on. I mean, I'm a firm

believer in asking your friends to look at you papers before you submit them to a journal so you can get rid of the stupid mistakes.

There's also typos which, as you probably know, if you've been working on a document for

months, you no longer see all of the words, so there can be some horrific typos. Spell checkers help a lot, but you know, sometimes there are whole words that are wrong or

just ‘the the’ that kind of thing that you just don’t see anymore after you’ve been working on something for a long time.

Appendix D

Portion of Interview Coding Tree Related to Lab Books

I. KNOWLEDGE CONSTRUCTION

1) Knowledge-Making Genres

(1) Lab Book

(a) Rhetorical Purpose

(i) doing research

1. recording configurations of experiments
2. creating and recording graphs
3. recording data outputs

(ii) developing research

1. making notes
2. sketching geometries
3. deriving equations

(2) Research Grants and Proposals

(3) Conference Papers

(4) Journal articles

2) Rhetorical Awareness

(1) of Lab Book

(a) audience awareness

(i) writing for "future self"

(ii) writing for knowledgeable members of the discipline

(iii)writing for non-specialised audiences

(b) readability

(c) knowledge of genre conventions

(d) awareness of tension between the lab book and activity

II. COMMUNITIES OF PRACTICE

1) Enculturation into Community

(1) Collaboration

(a) Lab Book

(i) working with colleagues

(ii) working with students

(b) refereeing

(c) developing shared resources

2) Shared Ways of Doing

(1) Conventions for Researching

(a) writing simulation programs

(i) using proprietary scanner information recorded in lab book

(b) running simulations

(c) producing scanner images

(i) recording images in lab book

(2) Conventions for Presenting Research

(a) accepted ways of presented information in graphs

(b) accepted ways of presenting equations

III. PROFESSIONAL IDENTITY

1) Formation of Professional Identity

(1) Participating in Research Work

(a) developing research

(b) working with experts

(c) working with other "novices"

(i) developing teaching awareness

(d) working with outside institutions (cardiovascular centres, hospitals)

(2) Presenting Research at Conferences

(3) Publishing Research in Journals

2) Maintaining Professional Identity

(1) Teaching and Mentoring

(a) awareness of student needs

(b) teaching genre conventions formally and explicitly

(i) journal articles

(ii) referee reports

(c) teaching genre conventions informally, implicitly

(i) lab book conventions

(d) "training" future medical physicists

(i) using graphs

(ii) using the lab book

(2) Expert Member

(a) awareness of expectations of medical physics community

(b) awareness of "goings on" in the medical physics community

(i) staying current with research

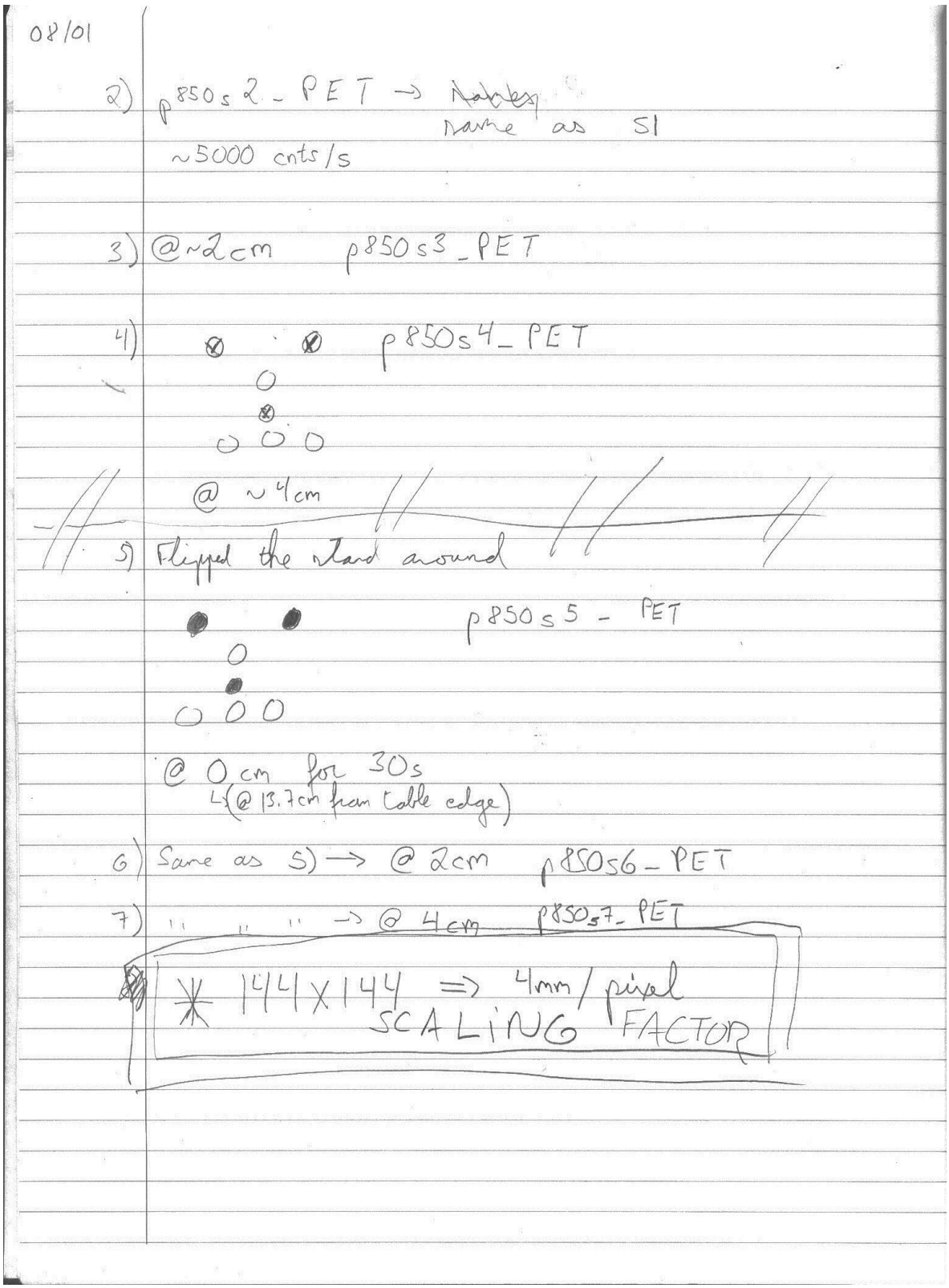
(ii) knowledge of practices

(c) awareness of genre conventions

(d) refereeing

Appendix E

Full Lab Book Entry Detailing Sean's PeTracker Experiment



08/01

2) p850s2_PET → ~~Nakley~~ name as S1

~5000 cnts/s

3) @~2cm p850s3_PET

4) p850s4_PET

@ ~4cm

5) Flipped the stand around

p850s5 - PET

@ 0 cm for 30s
↳ (@ 13.7cm from table edge)

6) Same as 5) → @ 2cm p850s6_PET

7) " " " → @ 4cm p850s7_PET

* 144X144 ⇒ 4mm/pixel
SCALING FACTOR

08/01

8) @ 6 cm p850s8_PET

9) @ 8 cm p850s9_PET

~~10) @ 8 cm / Sinogram~~

10) @ 23.85 cm Sinogram acquisition p850s10_PET
t = 30s

11) Same as #10 → List mode acquisition p850s11_PET

12) @ 22 cm p850s12_PET

13) @ 20 cm p850s13_PET

14) @ 18 cm p850s14_PET

15) @ 16 cm p850s15_PET

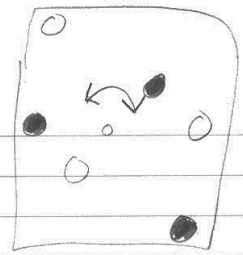
16) @ 14 cm p850s16_PET

17) @ 12 cm p850s17_PET

18) @ 10 cm p850s18_PET

08/01

19&20)



Rotation

p850s20_PET

Speed # 2

⇒ First ~10-20s → ϕ motion

(BAD RUN)

20) p850s20_PET → 50s → 0-10s : ϕ motion
10-40 : speed # 2
40-50 : ϕ motion

22) p850s22_PET → 50s → ~~0-10s~~ same

Speed # 3

23) p850s23_PET → Speed # 4