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USING DIGITAL SUPPORT TO ASSESS & PROMOTE EVENT-BASED SELF-REGULATION FOR CELL IDENTIFICATION

MA **Thesis**

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Abstract

Using Digital Support to Assess and Promote Event-Based Self-Regulation for Cell Identification

This action research intervention was conducted on 23 third year University students in the last eight weeks of teaching, as an intervention for the sustained failures in a named task. The main objectives were two-fold: to assess and promote student task-based self-regulation for cell identification, by determining learners' study patterns and to support students cell identification skills. In practical terms, task-based surveys (adapted from Endedijk et al, 2006) and video recordings (study guides) were digitally distributed to students. Alongside regular teaching and video access, students made self-judgements if learning occurred for the weekly task by submitting the relevant survey. All participants' digital traces were grouped as first timers (first attempt of task) or redoers (attempted task more than once). This digital footprint was defined by the type and amount of surveys completed with number of video logins per group. Study patterns were defined as learners' digital footprint and learning patterns. According to Zimmerman, Pintrich & Boekaerts' models both groups demonstrated portions of the preparatory and self-appraisal phases. Semi-structured interviews with six participants (three from each group) revealed the learning patterns present (Vermunt and Vermetten, 2004).

All redoers perceived they learnt the weekly tasks compared to some first timers. The redoers had four times more video logins than the first timers. Both subgroups demonstrated all criteria associated with meaning-directed learning and application-directed learning. Unlike the redoers, the first timers demonstrated a third learning pattern: undirected learning.

To counteract the failures, efforts to foster meaning-directed and application-direct learning will promote the *"…deep learning, critical thinking, independence, self-regulation…"* required in higher education (Vermunt and Vermetten, 2004, pp. 287-288). Also, incorporating tools that support task-based self-regulation within assessments could enhance metalearning in students (Colthorpe, Zimbardi, Ainscough and Anderson, 2015) and stem the failures noted.

Keywords

learning patterns; digital footprint; self-regulated learning; event-based

Contents

Introduction

Education in the 21st century retains aspects of the industrialized revolution that parented it, but the digital revolution that has since occurred and whose shadow and aftermath are ongoing, necessitate successful infiltration of a post-modern educational structure (Aviram, Ronen, Somekh, Winer and Sarid, 2008). Initiatives created to make this shift towards digital integration (and eventual competence) are ongoing but as technology continues to improve upon itself, the definitions of computer literacy and digital literacy become entwined with the human counterpart (Hoffmann, Lutz & Meckel, 2015). At the turn of the century, terms such as digital natives and digital immigrants became a way of differentiating the potential of human beings to interact with the ever evolving and encompassing technology (Prensky, 2001). This nomenclature became aligned with internet experience, education and age, such that baby boomers and millennials were called digital immigrants and digital natives, respectively (Prensky, 2001). However, Hoffmann, Lutz & Meckel, (2015) identified an additional user group that showed deviations from the generational classifications, for example some baby boomers adopted digital skills previously assigned to millennials were dubbed naturalized digital (immigrants).

Two decades into the 21st century, there is a digital divide exemplified in the classroom between teachers and students (Feldstein and Hill, 2016). When the expectations of these stakeholders do not align and becomes a barrier to teaching and learning, friction occurs (Mishra, Koehler and Kereluik, 2009; Vermunt and Vermetten, 2004). With this background of a digital mismatch between teacher and student expectations, student self-regulation and self-directedness becomes relevant to their immediate and long-term success, especially as the world now requires citizens to be lifelong learners (Aviram et al, 2008).

Task-Based Self-Regulation & Conceptual/Procedural Scaffolding

Self-regulated learning (SRL) is the vehicle by which students are actively engaged and control their learning process (Cosnefroy and Carré, 2014). Evensen, Salisbury-Glennon and Glenn (2001) assert curricula nowadays often require learners to be self-regulated, but their structure often opposes the development of positive self-regulation in learners. Indeed, self-regulated learning is best suited for children, adolescents and students with learning activities (Cosnefroy and Carré, 2014). Initiatives such as the Programme for International Student

Assessment (PISA)[1], aim to transform education at the adolescent level. However, it was only in 2019 that Jamaica became aligned with PISA, so systematic and coordinated transformation are not likely to exist yet (Evensen, Salisbury-Glennon and Glenn (2001); Hendricks, 2019).

Of the many models that represent SRL, the ones that most inform this study are those proposed by Zimmerman, Pintrich and Boekaerts. Including the assessment of learner self-regulation in this study aims to engage the learner about the specific task being carried out, since doing so helps to situate the learning process with the learner (Houde, 2006). Assessment of self-regulation in a specific event can be achieved using an offline tool wherein the cognitive, motivational, behavioural and metacognitive processes used by the learner are engaged without disturbing the learning activity (Endedijk, Vermunt, Brekelmans and den Brok, 2006). In so doing an overview of the learners' perceptions of any task can be obtained, for example these self-reports can reveal if learners perceive learning to have occurred (Veenman, 2005).

According to Quaye and Harper (2010) successful SRL requires the presence of scaffolds to support learners becoming self-regulated and promote learning of the subject matter. Included in this study are metacognitive, procedural and conceptual scaffolds by way of an offline tool and novel, copyrighted study guides designed specifically to simplify the complex learning task of cell identification into worded problems with solutions.

Using Learning Analytics (LA) to determine the Digital Footprint

As an interdisciplinary science, LA incorporates data science, areas of cognitive psychology, educational technology and education to permit the collection of *"…traces that learners leave behind and using those traces to improve learning."* (Duval, 2012). Digitizing both SRL surveys and the guides aimed to obtain responses from interested students to determine learners' event-based SRL and study patterns, in a convenient manner and from a distance (Spector, Merrill, Elen and Bishop, 2014). The digital platform also provides a degree of anonymity and freedom between the researcher and students, while permitting collection of their digital footprint.

Problem Statement

The complex learning task White Blood Cell (WBC) identification is a foundation

[1] PISA, includes Mathematics, Science & Reading tests administered every three year to 15-year-olds of member and non-member countries to evaluate their education systems.

competency of Haematology practicals and yet cell identification skills of Haematology Practical 1 & 2 learners at University of Technology, Jamaica (UTech, Ja) have worsened over the last four years. Anecdotal evidence from Teachers reveal the student's inability to correctly identify WBC's in Haematology 2 Practicals is the major contributor to yearly failures (e.g. from 2016 until 2019, failures per year were 11%. 22%, 71% and 34%). Failures in subjects like this one impact student throughput wherein their graduation is prolonged by at least one year. Another negative consequence is seen in the financial strain on the finite human capital and infrastructural resources of the School. These students who fail (redoers) must join the upcoming students (first timers), without the proportional add-on to the resources.

Justification & Importance of the Problem

The complexity of the learning task requires weekly sessions for a minimum of seven weeks. When reviewed systematically for possible intervention, the factors cited by students are categorized as issues with the rigid curriculum, administration, materials/resources being used and their workload. The curriculum's content is standardized by the professional organizations within the Caribbean and internationally, so changes are not readily possible. The length of teaching time and duration of classes are not a realistic parameter for change. The repeated daily use affects the microscopes, but they are functional. The already impressive student workload (that sees them in classes for eight to 14 hours on some days) becomes overburdened when redos are necessary; since student cognitive load becomes increased (Kirschner, Sweller and Clark, 2006).

This predicament shows no signs of abating. The consistent failures impact student retention, student throughput, class sizes (student redoers alongside first time learners), teacher workload and the potential graduate employment rate. The new *status quo* creates a potential bottleneck for two reasons: failures can only be re-done one year later also, class size numbers increase as redoers join first timers, without the proportional increase in resources.

Significant to this discussion is the financial constraints present in the Jamaican landscape. Interventions such as this classroom action research must be economical while identifying solutions to address the authentic classroom issues noted (Spector, Merrill, Elen and Bishop, 2014).

Operational Definitions of Key Terms

Digital Footprint. As a contemporary term born from the digital revolution, it refers to the specific, digitally traceable information that exists on the internet because of humans' digital activity (TED, 2014). For the purpose of this study, the digital footprint of these participants refers to their unique electronic signature resulting from the type of survey chosen and their responses (data on the individual level) and video login activity (data from the system level). A partial digital footprint is one that has either one complete survey or at least one video login (but not both). A complete digital footprint refers to at least one complete survey and one video login. The digital footprint can be described in terms of degrees of robustness, for example the type of survey chosen (learnt versus did not learn), the quantity of surveys completed (one, two or three) and total number of video logins. Potentially all learners can complete a total of three surveys over the eight weeks, but there is unlimited access to the study guides.

A participant is a learner who produced either a partial or complete digital footprint and a student is a learner that left no digital footprint.

Study Patterns. According to Vermunt (1996, 1998), as cited by Vermunt and Vermetten (2004) learning styles or patterns is *"… a superordinate concept in which the cognitive and affective processing of subject matter, the metacognitive regulation of learning, conceptions of learning, and learning orientations are united."* (p. 362). The types of learning patterns identified include reproduction-directed, meaning-directed, application-directed and undirected learning (Vermunt and Vermetten, 2004). For the purposes of this research, the term *study patterns* encompass the definition of *learning patterns* (LP) along with participants' unique digital footprint. Therefore, study patterns that support learning of the complex learning task in this research refer to processing strategies, regulation strategies, conceptions of learning and learning orientations/motivations used by the participants and are captured by their responses in the semi-structured interview alongside their digital footprint (see Appendices F & I).

Research Objectives & their Rationale

The main objectives of this study were two, to: a) assess and promote student task-based self-regulation for WBC Identification and b) support students in acquiring WBC identification skills. The categorization of the population into first timers and redoers was

designed to consider students' exposure to the content regarding this current task and their subsequent study patterns (Vermunt and Donche, 2017).

To operationalize these objectives the following six sub-goals were developed, to: 1) use Google Forms to establish the redoers from first timers and establish their baseline responses for the offline, task-based self-regulation questionnaire (TSRQ) at the beginning of the intervention, i.e. week one of the study. 2) create the worded story problem/answer guides. 3) create video-versions of the study guides, embed within Google Forms and give unlimited access to students. 4) use Google Forms to establish student responses (redoer and first timer) for the offline TSRQ midway and at the end of the intervention, e.g. weeks three and eight of the study. 5) use the digital footprint of the participants (their TSRQ responses and their video logins) as exclusion criteria to create a list of participants for interviews. 6) use participants' digital footprint and interview responses to determine their study patterns for this task.

The first and fourth objectives are to **assess** student task based SRL throughout the study, with the distribution of the questionnaire multiple times in the study (e.g. weeks seven, nine and 14 of the teaching semester). The second and third objectives purport to **support** task based student SRL by using an aid to enhance the content taught in the weekly face-to-face sessions. The conversion of the guides into video format also lent support to the SRL process in the form of procedural scaffolding. The fifth and sixth objectives aim to **define the study patterns** of participants from the triangulation of the data collected. Therefore, **assessing and promoting task-based SRL** was accomplished by determining participants' study patterns throughout the study.

Research Questions

1) What did the offline TSRQ reveal for the self-reporting, self-regulated learning activities for redoers and first timers throughout the intervention?

2) Which study patterns were revealed by the interviewees' digital footprint and interview responses?

Brief Overview of the Thesis Structure

The following sections of the thesis involve analysis of SRL and learning patterns in a systematic review of studies that informed this one. The subsequent chapters detail the methods used, results, discussion and conclusions for this action research study.

Theoretical Background

Embedded within the improvement of a specific set of skills, this project aims to determine, measure and track student self-regulation of a specific complex learning task. Learning analytics was used to capture student access to learning material and their perceptions of learning for the duration of the research.

SRL in this Study (Zimmerman, Pintrich & Boekaerts' Models)

Active participation of learners within their learning process, learners' thoughts, feelings, actions are planned and adapted *"…to attain a self-selected goal"* (Zimmerman, 2000 as cited by Colthorpe, Zimbardi, Ainscough and Anderson, 2015, p. 134). Of the many SRL models that exist, most share three general phases in common: preparatory, performance and appraisal (Puustinen and Pulkkinen, 2001). Governing these phases are several regulatory processes, namely (meta)cognition, motivation and emotion (Panadero, 2017).

Zimmerman's model focuses on the cognitive and social aspects of the learning process. Defined as personal responsibility and emotional regulation with other concepts such as self-efficacy, Self-Regulation refers to personal agency in whatever situation is being faced by the individual where there is a reciprocal determinism of the environment on the person (Boekaerts, Zeidner and Pintrich, 1999). Whereas Zimmermans' model emphasizes SRL as a 'goal-driven activity', Pintrich's model characterizes SRL in similar terms but focuses on the *"regulation of cognition"* (Panadero, 2017, p. 19). Based upon goal processes of the learner, Boekaerts' self-regulation model focuses on the learner's appraisal of the task such that the ego is protected (Panadero, 2017). Boaekaerts' model focuses on the interaction of the learner with the environment resulting in goal setting, goal striving and then ultimately a choice is made that determines behaviour - mastery/growth (top-down) or well-being (bottom-up). However, this process is not linear as continuous cognition of the task allows the learner to act in a manner that always protect their ego (Puustinen and Pulkkinen. 2001).

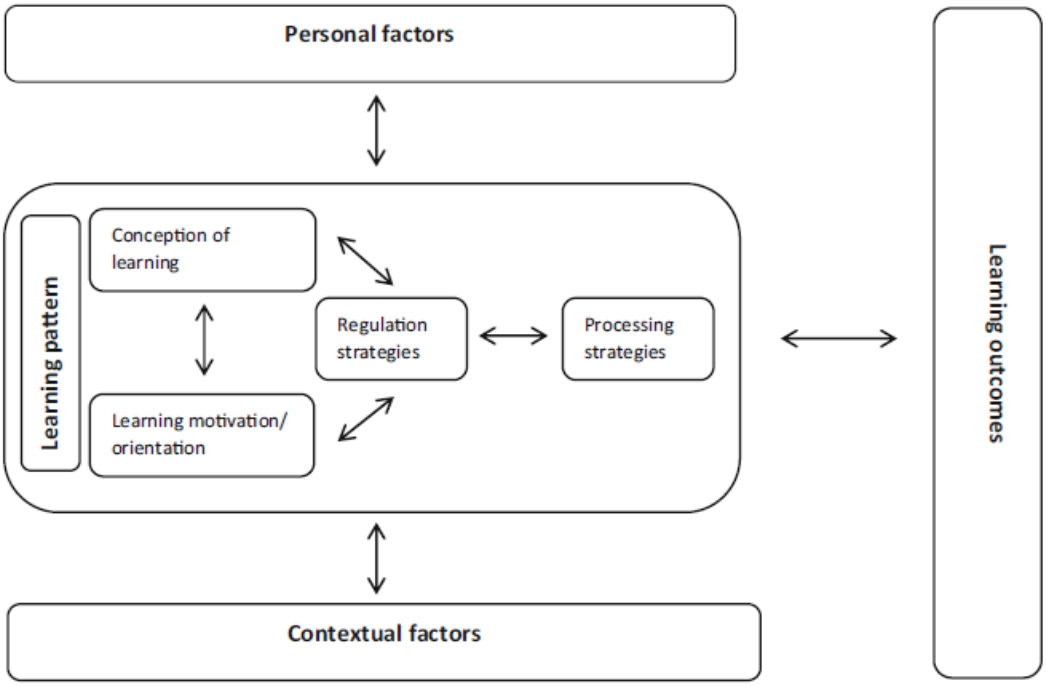
These three models propose finite, identifiable aspects of SRL that when applied (via an intervention) can result in targeted and observable effects (Panadero, 2017). Therefore, this trio of models were used to adapt Endedijk et al's 2006 survey to develop the TSRQ's used in this research. This approach seeks to identify SRL activities (in terms of these models) that already exist in the student cohorts (redoers and first timers) and track them over time. Multiple distributions of the TSRQ's were inspired by Schmitz' (2011) time-series analysis with learning diaries, wherein an effective impact on all SRL phases and student performance

was noted (as cited by Panadero, 2017). Additionally, the ability to self-judge and determine if learning occurred on a weekly basis adds a layer of SRL support through self-monitoring and learner (meta)cognition about the learning process that accrues over time, comparable to learning diaries.

Learning Patterns in Student Learning in this Research

In the current paradigm, learning is no longer limited to traditional educational systems and the concept of lifelong learning is relevant (Aviram et al, 2008). Models, phases and processes of SRL support learning, but the concept of learning must be defined first before it can be supported. Vermunt and Vermetten (2004) sought to define learning in terms of specific styles (now called patterns) to characterize learners (from higher education) and their learning experience in a model that is *"multidimensional and grounded in students' experiences of learning in normal study settings"* (p. 275). The learning patterns identified learning components involving cognitive processing strategies, regulation strategies, conceptions of learning and learning orientations/motivations (see Figure 1); their definitions and interrelations add a depth to comprehending learning (Vermunt and Vermetten, 2004).

Figure 1. Vermunt and Vermetten's (2004) Learning Patterns Model of Student Learning.



These four learning components (domains) were used to create a tool called the Inventory Learning Scale (ILS) that was further defined by five scales for each domain to yield a 120-item survey to determine students' learning patterns (Vermunt and Donche, 2017). The resulting four learning patterns are based upon real-life, authentic student experiences, seeks to categorize patterns in learners and is a broader conceptualization of learning (than the previously mentioned SRL models) and includes aspects of SRL (Vermunt and Donche, 2017).

The learning patterns derived from the learning components identified are undirected learning, reproduction-directed learning, meaning-directed learning and application-directed learning (Vermunt and Vermetten, 2004). Viewed on a spectrum with undirected learning and application-directed learning on opposing ends, reproduction-directed and meaning-directed learning are located (in that order) between them. As learning moves along that spectrum going towards application-directed learning, it is seen as less automatic and more synthesis-based (Vermunt and Donche, 2017). An undirected learner has problems knowing how to approach learning and is characterised by lack of regulation, ambivalent learning orientations and places emphasis on external sources to stimulate their learning process. Subsequently, a reproduction-directed learner learns to pass assessments, so that what they produce varies very little from what they were taught. Reproduction-directed learning is characterized by seven criteria among which are stepwise processing and external regulation (see Appendix I). The meaning-directed learner goes deeper and further with learning (than the reproduction-directed learner) by trying to find the meaning of what they learn, and they try to structure this information into the greater whole to get a fulsome picture. These learners are identified by six criteria from the ILS and includes deep processing and self-regulation to name a few (see Appendix I). Culminating in the application-directed learner, this student displays aspects of the meaning-directed learner but takes the information taught and situates it into their daily lives to identify relevance to a current job or a new one. Two characteristics that represent this learner type include concrete processing and vocation learning orientation (Vermunt and Donche, 2017). The grouping of criteria associated with each of the four learning patterns are discrete, but how they are represented in learners may vary. Some learners can show all features of one pattern or exhibit several criteria from multiple patterns (e.g. ≥ 2); the scales of learning patterns are not mutually exclusive (Vermunt and Donche, 2017).

As seen in the learning pattern model in Figure 1, personal and contextual factors independently influence the overall learning pattern of a student. Examples of personal

factors include age, content knowledge, educational experience and contextual factors may include teaching methods used, assessment types included and opportunities to collaborate with students (Vermunt and Vermetten, 2004). The subdivision of the students into redoers and first timers for this study serves to create homogenous groups based upon their personal factors, where each group acts as a dependent variable in this research.

Considering the necessity of lifelong learning in the 21st century, higher education institutions that foster meaning-directed and application-directed learning and thinking will promote the *"..deep learning, critical thinking, independence, self-regulation…"* and use of knowledge to benefit the global society (Vermunt and Donche, 2017, pp. 287-288). Understandably, to foster these types of learning and thinking patterns congruence is needed in the interactions of all educational stakeholders involved. Where congruence between students' learning strategies and teachers' teaching strategies is absent, friction develops (Vermunt and Donche, 2017). Destructive friction can refer to *"…when the distance between the level of self-regulated learning that the teacher expects from the students, and the self-regulatory skills these students possess, is too great…"* (Vermunt and Vermetten, 2004, p. 363).

Although out of the scope of this study, it is acknowledged that self-regulated interventions aimed at students without considering their specific context fails to address the environmental limitations of SRL identified by Pintrich (Panadero, 2017). However, if friction of the type noted herein exists in this specific context it is argued that determination of learners' learning patterns present may provide information that can be used in follow-up studies to promote meaning-directed and application-directed learning and thinking.

Assessing Task-based Self-Regulation in this Action Research

The ability of andragogical learners to regulate their learning is essential to success (Loyens, Magda and Rikers, 2008). Included in this research design is a facet that engages the students' metacognitive processes while performing this action research. Action research provides a platform from which iterations to the original plan (that are specific to the students' responses on the surveys) can be made. Placing the instrument after content is taught, allows an evaluation (by the learner and researcher) of the learners' baseline perceptions of self-regulatory skills without interrupting the learning process (Endedijk et al, 2006).

Using LA to Assess & Promote Task-Based SRL in this Action Research

Colthorpe, et al (2015) used learning analytics' investigative processes to track student access to teaching material, collect their self-reporting assessment of their self-regulatory skills to show their impact on student's academic performance. Cognizant of the limitations present with SRL self-reports (Winne, 2010), this study used digital support to track learners' weekly access to learning materials to bolster their SRL survey responses and triangulated these data with learners' academic performance. However, not explicitly stated by Colthorpe et al, 2015 is if SRL was being assessed as an aptitude or an event which impacts the influence of their results. Also, the multiple SRL measurements made discovered the cohort studied demonstrated aspects of performance and self-reflection, but forethought was under-reported. However, upon closer evaluation the SRL tool used in this study it did not explicitly ask learners about goal setting. Such an observation could be attributed to issues with construct validity of the tool (Messick, 1989 as cited by Boekaerts, Zeidner and Pintrich, 1999), wherein underrepresentation of a construct on the tool (rather than its absence in the student) is the reason for under-reporting. However, noteworthy is their observation that the triangulated data demonstrated high academic performance was positively associated with early submission of summative tasks, rather than frequent digital access to learning materials.

Endedijk et al's (2006) study sought to assess task-based SRL in eight student teachers, using four offline SRL tools they developed – portfolios, concrete experience interviews, portfolio interviews and task-based questionnaires: week reports. When assessing all four tools for their ability to measure all areas/phases of SRL, formal/informal learning and intentional/unintentional learning, the week reports were most effective followed by concrete experience interviews. The limitations noted with the week reports as designed included the need to be assessed on a larger sample size and to be used in other studies with complex learning environments. Indeed, final recommendations from this study were to improve the week reports designed to prevent misunderstandings that occurred. Another suggestion made was to limit the learning experience being measured per week, to ensure all responses received for analysis were on the same learning experience.

This action research was inspired by the work of Endedijk et al, 2006 and Colthorpe et al, 2015 supplemented with a simple worded problem-and-answer study guides created to enhance the unique vocational skill in the classroom issue noted. Identifying and tracking traces of learning on a system and student level provides another (often under emphasized) perspective in the teaching and learning environment - the learner's viewpoint, as captured by

the learner and not a second-party interpretation of student learning as is the case of personalized learning (Murphy, Redding and Twyman, 2016).

Also, promoting an environment that reinforces SRL requires providing support and guidance to the student in the form of process worksheets, prompts, modelling and feedback to make learning visible (Hattie, 2012; Spector, Merrill, Elen and Bishop, 2014); such that including the study guide in this action research promotes self-regulation, while assessing it via the TSRQ. Indeed, Loyens, Magda and Rikers' (2008) review article reports the use of problem-based learning encourages self-regulated and self-directed learning, with the latter being more closely associated with success in problem-based learning. Including worded problems and their solutions purports to enhance not only students' skills in cell identification but also bolster students' self-regulatory skills.

Using SRL models in this study offers a unidimensional and ideal way of learning (Vermunt and Donche, 2017) that is poised to enhance learning, however including the learning patterns model in this study bolsters the goals of this effort by identifying discrete patterns present. Incorporating both concepts in this action research will provide a baseline determination of the learning patterns and SRL skills present in the two learner cohorts, to inform the iterative nature of this research (Ary, Cheser, Jacobs, Sorenson, and Walker, 2014). Raising student awareness of their own learning, known as metalearning (Colthorpe et al., 2015), and the self-regulatory skills they (un)knowingly use for this complex learning task is a plausible outcome. Another benefit of including the LP model in this study is seen in the authentic learning components provided, such as external regulation and lack of regulation. External regulation refers to the learner who lets sources external to them guide their learning and lack of regulation considers the learner who is unable to successfully self-regulate (Vermunt and Vermetten, 2004). Since these facets of self-regulation undoubtedly exist in some learners but are not explicitly covered in the SRL models, a realistic depiction of these learners' learning patterns is expected when using the LP model in this study.

Being able to apply the tools of LA to detect, track and measure learning activities, especially those that are embedded within complex learning tasks is the kind of focus that Endedijk et al (2006) assert as being needed for the lifelong learners of the 21st Century. This effort seeks to provide answers to the classroom issue noted while promoting SRL and the specific skills stated with methods relevant to (and that promote) lifelong learning.

Methodology

Experimental Setup

This action research study was conducted over the last eight weeks of the 2019/2020 teaching semester for the module "Haematology 2 Practical". The participants were university students (older than 17 years) from the Medical Technology department at UTech, Ja. Permission to conduct the study at UTech, Ja was obtained from the Dean of the College and informed consent was obtained from the Classroom Manager and Dean via the informed consent form (see Appendix B). No incentives for students to participate in this study were offered.

Of the 38 consenting students, there were seven males and 31 females; nine persons failed this module at least once before (redoers) and the rest were first timers. The goal of this exploratory study was to assess students' self-reporting, event-based self-regulation skills for the complex learning task, WBC identification. Simultaneously, students were provided with a conceptual scaffold (WBC study guides) to enhance their learning of the skill. Students' SRL self-reports for this complex task was assessed by using an adapted questionnaire created by Endedijk, et al (2006). This TSRQ required participants to determine whether learning occurred in a specific class by selecting one of two surveys, then responding and submitting same digitally (see Appendix C). The conceptual scaffold was created and provided to support self-regulated and domain-specific learning. These aids took the form of three study guides designed to embody laws and rules with subsequent simple worded problems/solutions, to help create schemas of learning for WBC Identification (Jonassen, 2000). For ease of comprehension, the study guides were recorded as videos for use in this study (see the online repository). The digital platform was used to create, distribute and collect data from the TSRQ's and the study guide videos. Digital platforms such as Google Forms, Zoom, YouTube and the computer software program, Microsoft PowerPoint were used in the creation process. Students' digital footprint was captured and used to assess the goals of this study. All data collected from participants were anonymised except for their identification numbers, email addresses and first timer/redoer status for this subject. All semi-structured interviews were conducted and taped with Zoom; wherever the participant preferred not to use their camera that was supported (see online repository).

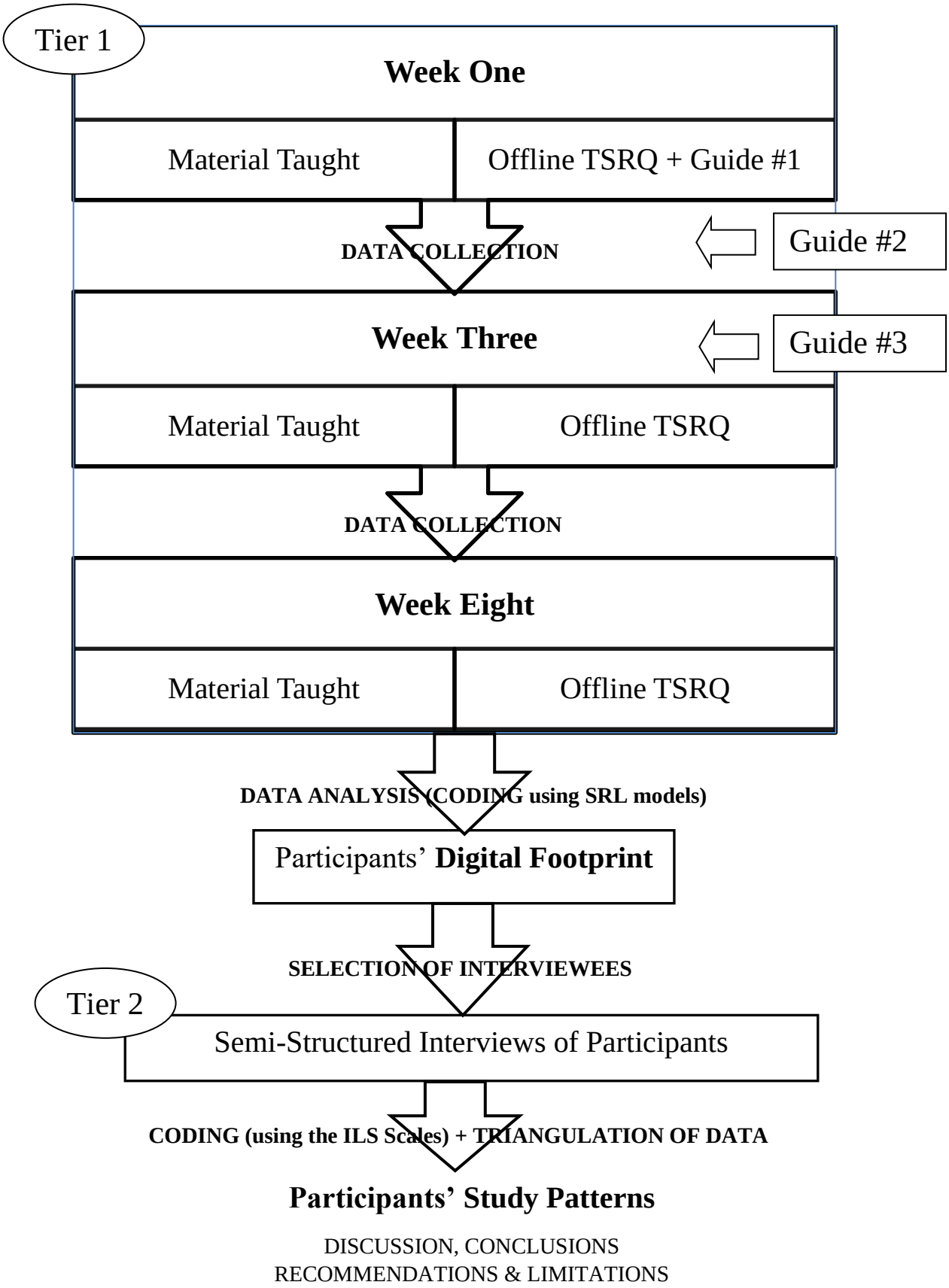
Procedure

Students were introduced to the purpose of the research and oriented to the digital platform where the guides and questionnaires were uploaded. Data collection via the digital platform

(frequency of student logins per student, the type of and amount of individual TSRQ responses) started immediately (see Figure 2). Throughout the eight weeks, there were three interventions. (weeks one, three and eight of the study). Each intervention occurred after content was taught and an assessment given by the Teacher. The intervention included student access to two types of TSRQ's, and the video scaffolding aids. After students were taught the weekly content, they were asked to select, complete and submit the relevant survey, by deciding if they thought they learnt or did not learn the concept/task taught that week. Student access to the digital study guides and completed survey responses were tracked by use of their unique identification number and together comprised their digital footprint. The videos were introduced incrementally over the first 3 weeks of the intervention and once uploaded they remained open for the entire eight weeks (with unlimited access). However, the surveys were opened only three times for the study and remained accessible for one week's duration each time they were opened, to guarantee student responses were all based on the same learning experience (see Figure 2). Overall, students had access to two TSRQ types for three weeks over an eight-week period, with the ability to select only one of the two surveys each week. The research design used permitted an iterative cycle of reflection, planning, action and observation wherein data collected weekly was analysed and used to make amendments to subsequent administrations of the questionnaire and study guides. The digital platforms used to administer both the questionnaires and guides also permitted the immediate adoption of changes, at no financial cost and with minimal effort. The design aligns with the tenets of action research and helped to inform how to proceed with data collection (Ary et al, 2014).

The first research question was answered by reviewing the TSRQ responses for the 20 participants (15 first timers and five redoers) and documenting the SRL themes present in this cohort. Their TSRQ responses were analysed for evidence of self-regulation specific to the task-in-question such as forethought, self-reflection, metacognition alongside coping processes determined by the specific learning context (Panadero, 2017). Participant numbers were further reduced by using exclusion criteria, such as whether learners produced a partial/complete digital footprint versus none. Students who left no digital footprint could not provide information in furtherance of this study, so they were excluded. Comparison of the data sets from tier one of data collection permitted the exclusion of 15 students from the 38 registered students, because they left no digital footprint. Of the remaining 23 participants, eight left partial digital footprints and 15 had complete digital footprints (see Appendix G).

Figure 2. Research Design for this Action Research



Exclusion criteria focused the second tier of data collection on the 23 participants, but targeted efforts were made towards those who left a complete digital footprint. Multiple requests for interviews yielded five learners who had complete digital footprints (records reveal there were three redoers and two first timers). Deliberate efforts to seek another first timer resulted in one who had a partial digital fingerprint, (no video logins recorded). Six participants consented to participate in follow-up semi-structured interviews to elaborate upon their overall study patterns for this task.

To answer the second research question content analysis and coding of interviewees' responses was completed using the abbreviated Taylor-Powell & Renner approach (Cotton, 2016) and the ILS characteristics, scales and definitions (see Appendix H). The smallest unit for data analysis was portions of sentences. The data was reviewed line-by-line to group the responses according to the ILS definitions (Vermunt and Donche, 2017) and the four learning patterns (Vermunt and Vermettten, 2004) were determined to identify the learning patterns present in the two categories (redoers and first timers).

The learning patterns and digital footprint of redoers and first timers were used to determine the collective study patterns of the redoers separate from the first timers interviewed.

Instruments

Offline Task-Based Self-Regulation Questionnaire (TSRQ).

An offline task-based self-regulatory questionnaire developed by Endedijk et al (2006) for their study of Dutch-speaking student teachers was identified for use in this study; however, the language style used by these authors differs from that spoken by Jamaicans. Participation and responses to a survey can be impacted by nuances in the respondents' dialect that could interfere with survey cooperation and jeopardize data quality (Renschler and Kleiner, 2013). Also, the presence of cultural differences in education between both countries must be acknowledged and addressed (Spector, Merrill, Elen and Bishop, 2014). Therefore, the questionnaire was adapted for the Jamaican dialect and language style of the intended population of this study. Questions were also added to anchor the questionnaire in this action research effort; specifically, questions to determine the students' identification number, status (first timer versus redoer) and to solicit their assessment of the study guides (see Appendix C, namely items 1, 20, 21, 22, 24, 25 and 26). Students' identification numbers are included to permit tracing of their individual responses throughout the study to answer the research

questions. The students' status was needed to evaluate how each category of student viewed the intervention, where one category could have a different view of the learning process since they have been exposed to the content previously (Vermunt and Donche, 2017). Coined as Classroom Action Research by Ary et al (2014, p. 516), this effort aims to *"improve classroom practice"*. Differentiating student experiences into these categories aims to deepen the potential effect of this intervention by defining each student's experience to put support in place to meet them where they are in the learning process, in future studies.

An offline tool for measuring self-regulated learning (SRL) was chosen for this study in accordance with recommendations when interacting with potentially biohazardous material, as outlined in the Occupational Safety and Health Act (2017). Online SRL tools pose public health challenges in Biomedical Science practicals due to the interruption of learning while students handle potentially biohazardous material. Also, the convenience offered by an offline SRL tool allowed students the flexibility to determine any point in the week (after their lesson) to access the digital platform for completion of the survey (see Figure 2). Endedijk et al's (2006) 10-item offline survey focused on the student who learned, with two alternate items included for the student who did not learn (see Appendix D). The fourteen-year old survey included items that addressed the three areas of SRL as posited by Pintrich (Boekaerts, Zeidner and Pintrich, 1999) and the three phases of the regulation process as outlined by Zimmerman (Panadero, 2017).

The 23 to 26-item adapted offline TSRQ was used in this study to assess if learning did or did not occur, according to the student. Endedijk et al's (2006) original questionnaire was modified to include close-ended conditional questions to permit its adaptation to Google Forms (see Appendix C, items 4 and 5). Other modifications were made to permit student elaboration of responses to minimize response bias by providing multiple opportunities for them to express themselves. For example, items 3, 4 and 5 in the 2006 survey (see Appendix D) became items 4, 5, 6, 7, 8, 9 and 10 (see Appendix C). Since the high failure rate for this task is a driving force for this study, the survey items were expanded and tailored to uncover students' thoughts and behaviour regarding this task. Metacognitive scaffolds were provided through specific items on this offline digital TSRQ that prompt the learner to reflect on their learning experience (see items 4, 5, 6, 8, 9, 10, 11, 18 and 19 in Appendix C) and self-monitoring (see items 7, 16 and 17 in Appendix C). The TSRQ's used are adapted from Endedijk, Vermunt, Brekelmans and den Brok's (2006) 10-item version and possesses 23 and 26-items; the former asks learners to determine if they learnt the task that week and the latter

if they did not learn. The judgment to choose the questionnaire that applies to each student is made based on their own assessment of learning of the task for that week.
The two links for the Google Forms surveys were presented to the student via email (after teaching was done for that week). To help students decide which survey suited their learning experience that week, pdf files of both surveys were attached to the email so the type of questions required of them could be known prior making their selection. If students' thought learning occurred that week, they were instructed to access the 23-item questionnaire, complete and submit their responses. If students' thought learning did not occur, they were asked to access and submit their responses to the 26-item questionnaire. Although access to both surveys was granted, only one response per student, per week was permitted. The surveys were administered three times for the eight weeks (see Figure 2).

WBC Study Guides/Tutorial Videos.

Study guides aimed at documenting the concepts taught in WBC Identification into an artifact is a novel concept. Using algorithmic-like problems that are situated in a specific context (also known as worded problems) could potentially simplify aspects of this complex learning task (Jonassen, 2000). Also embedded within the study guide is procedural information to permit the automatization of routine tasks (van Merriënboer. Clark and de Croock, 2002). In so doing routine steps required in solving the worded problems are repeated for emphasis throughout the process, which could help reduce learners' cognitive load while performing this complex learning task (Kirschner, Sweller and Clark, 2006).

The concepts in the study guides and how to use them were recorded and created into a digital resource for student use (see the online repository). Learning was facilitating outside the classroom while occurring at the learner's pace, thus situating learning (away from the teacher and) in the andragogical learners' domain (Houde, 2006). The study guides acted as a conceptual scaffold to this self-regulated learning intervention and learning analytics was used to trace students' digital footprint while accessing the guide and questionnaires throughout the intervention.

Three study guides were designed – one based upon normal WBC morphology, another based upon pathological WBC's and the final one using images to practice concepts reinforced in the first two videos. The first guide was made accessible to students at the beginning, with unlimited access. The second guide was opened before the third week and the final guide was distributed in the third week (see Figure 2). Although the concepts organized

in the study guides have been used to build the teaching practice for this complex task, these guides are new and ideally should be pilot tested before use. However, the iterative nature of this action research provides a space to capture emergent issues, allow time for amendments and re-testing (Bhattacherjee, 2012).

Inventory Learning Styles (ILS) Definitions & Scales

The definitions and scales of learning components posited by Vermunt and Vermetten (2004) were used to analyse interviewees responses in tier two of data collection (see Appendix H and Figure 2).

Data Analysis

Data collected from both types of TSRQ's were converted to Microsoft Excel via Google Forms and analysed to provide a synopsis for the entire cohort of participants (redoer and first timer). Data from both types of TSRQ's were analysed based upon participant's responses to questions aligned with the three general phases of SRL models. The information was presented according to these three phases as a qualitative assessment of SRL for redoers and first timers to answer the first research question.

To answer the second research question, exclusion criteria reduced participant numbers to conduct semi-structured interviews. These interviews were conducted on a subset of eligible participants and content analysis done on the responses to determine these students' study patterns as it regards WBC Identification.

The participating population was summarized in terms of redoers and first timers with simple graphical representation from Microsoft Excel software.

Transcriptions of the interviews (see online repository) were completed, analysed by content analysis and coded using the qualitative ILS learning patterns to identify the learning patterns present (see Appendix J). The criteria used to define each pattern was used to determine the frequency of each pattern in the redoers and first timers as two, separate collectives. The learning patterns with all criteria demonstrated (see Appendix I) were identified as the main learning patterns in the redoer and first timer interviewees (see Appendices K & L). These learning patterns were triangulated with the respective digital footprint to determine interviewees' study patterns.

Results

Population Summary

Of the 38 students registered for Haematology 2 Practical for academic year 2019/2020, there were 29 first timers and nine redoers. Of the registered students, 20 (53%) completed at least one survey, the three times survey data was collected and 18 (47%) logged in to view the videos over the eight weeks (see Figures 3 and 4, respectively).

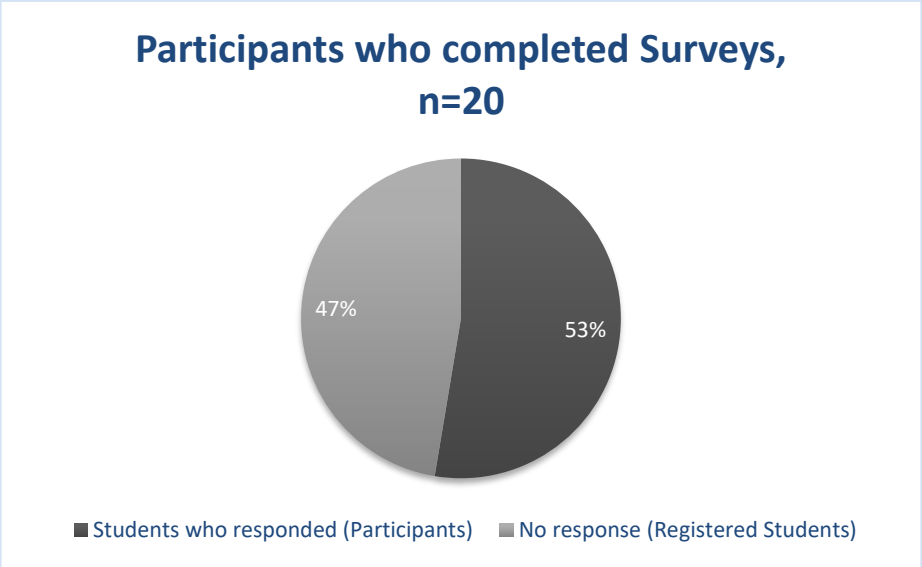


Figure 3. Participants who completed either Survey for the 8-Weeks.

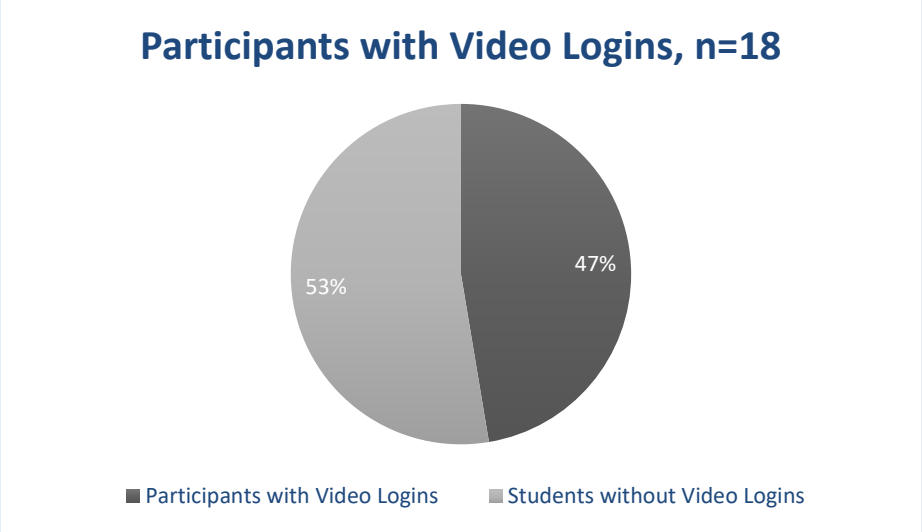


Figure 4. Participants who logged unto any Video for the 8-Weeks.

Of the 20 survey responses obtained, six (30%) were from redoers and of the 18 participants with video logins, six (33.3%) were redoers.

The survey responses throughout the study declined over time, with most participants indicating learning occurred throughout the study. Whereas the first two sets of data collected revealed participants selected either survey, the final week only demonstrated participants who believed they learnt (see **Figure 5)**.

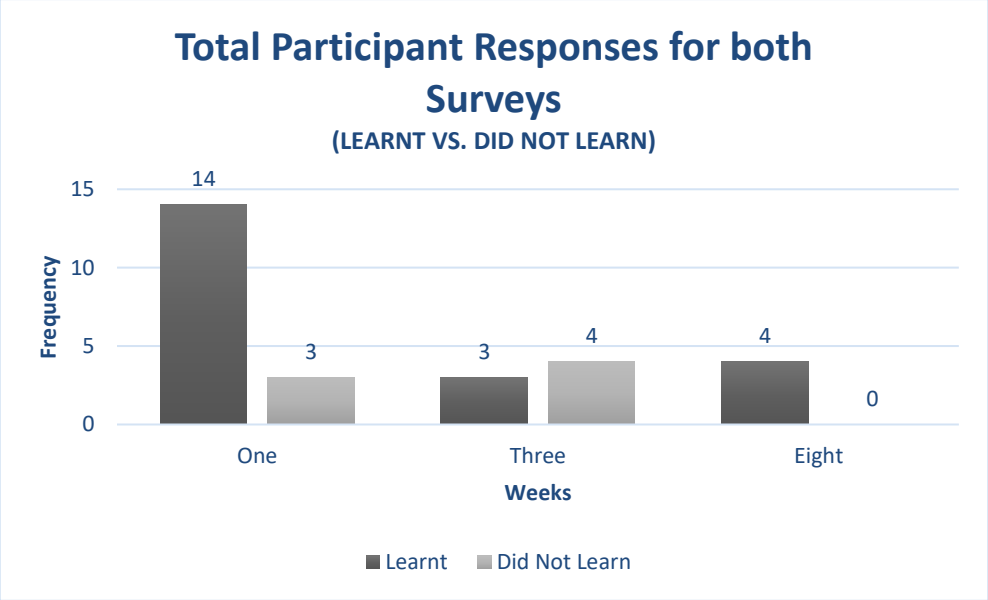


Figure 5. Total Participant Responses per Survey, per Week.

Almost half of the population of first timers (48.3%) and more than half of the population of redoers (66.7%) participated in this study.

Of the 20 participants, 18 perceived they learnt - 14 in the first week of data collection, three more responses in the third week and four in the final week of data collection (see Table 1).

For the participants who perceived they did not learn, all were first timers and their issues were noted in the first and third weeks of data collection. Of the 20 participants, six perceived they did not learn at specified times throughout the study (see Table 2).

Noteworthy is the observation that six students submitted multiple surveys throughout the study which purports to better determine participants' study patterns (data not shown).

A general, qualitative review of the survey responses from the six redoers and 14 first timers was done, specifically on items 4 to 23 for the participants who did not learn and items 4 to 19 for participants who learnt.

Table 1. TSRQ Responses for Redoers and First Timers who Learnt.

Participant Identifier	'Learnt' TSRQ's completed per Week		
	One	Three	Eight
AS(R)	L	L	-
TA(R)	L	-	-
MM(R)	L	-	-
AM(R)	L	-	-
KR(R)	-	L	-
SE(R)	-	L	-
JP	L	-	-
DCa	L	-	-
SA	L	-	-
CB	L	-	-
DW	L	-	-
KA	L	-	-
MM	L	-	-
KD	-	-	L
MI	-	-	L
SB	L	-	L
DCh	L	-	_
PM	L	-	L
Total	14	3	4

L, Learnt Survey; D, Did Not Learn Survey; R, Redoer

Qualitative Analysis

1) What did the offline TSRQ reveal for the self-reporting, self-regulated learning activities for redoers and first timers throughout the intervention?

Self-Reporting, Self-Regulating Themes for Redoers' Survey Responses

The preparatory and appraisal phases were assessed through survey items that stimulated responses about task analysis, goal setting, plans to achieve goals, motivational beliefs, self - reflections on current performance and future events. Although the three SRL models have

significant overlaps between them (Panadero, 2017), the redoers' responses were analysed based upon the SRL construct most emphasized in each SRL model, namely motivation (Zimmerman), cognition (Pintrich) and emotion (Boekaerts).

Table 2. TSRQ Responses for Redoers and First Timers who Did Not Learn.

Participant Identifier	'Did Not Learn' TSRQ's completed per Week		
	One	Three	Eight
AT	D	-	-
ST	D	D	-
MI	D	-	-
SB	-	D	-
DC	-	D	-
PM	-	D	-
Total	3	4	0

L, Learnt Survey; D, Did Not Learn Survey

Pintrichs' assertion of learners' *"judgements of learning"* and "*feelings of knowing"* (Panadero, 2017, p. 13) are evidenced in the research design by these participants thoughtfully assessing their performance retrospectively and selecting the survey that described their weekly experience (see Figure 2). The seven responses from redoers were obtained at the beginning and middle of the study (see Table 1). All indicated they perceived learning occurred for the weekly tasks; some themes noted were recognition of: *"[getting] the results correct"*, *"felt less struggle when performing the task"* and being *"able to explain the results to their fellow classmates"*. These statements are in support of Boekaerts' mastery/growth pathway that guide learners' behaviours towards learning due to positive cognitions and emotions (Boekaerts, Zeidner and Pintrich, 1999).

Each response was aligned with the survey item and the specific SRL construct named (see Table 3). Noteworthy is the observation that two redoers used the terms *"neutral"* and *"not much"* to describe their confidence/motivation after the learning task. However, when asked retrospectively to describe the environment where learning occurred statements made by the majority of being: *"in a good mood"*, *"willing to learn"*, *"well rested"*, *"in a receptive mood"* and *"[in a] room …conducive for learning"* were noted.

Table 3. Analysis of Redoers' Survey Responses for Zimmerman's Model.

SRL Phase	Survey Item	Redoers' Responses
Goal Setting	Did you have the intention to learn this task?	*"Yes"***(all 7 responses)**
Strategic Planning	Are you making new plans to learn more?	*"Yes"***(all 7 responses)**
	What is your next step after this learning experience?	*"Well I read my text and made notes of things that are important to the topic and I also watched the study guides to help with white blood cell differentiation"*
		"watch youtube videos as well as looked at google images of abnormal WBC"
Intrinsic Motivation	Why did you want to learn this task?	*"I do not want to fail hemat again lol"*
		"It pushes one to know more about the particular topic, and what is required of us students to identify the types of leukemic reactions, along with case studies which required critical thinking"
		"so i am able to pass the exam"
Outcomes Expectations	Did you believe that you were going to succeed at this task?	*"Yes"* **(6 responses)** *"I don't know"* **(1 response)**
Self-Evaluation	What do you think was important in helping you learn this task?	***"****I changed my mindset as it relates to hemat. I would always classify hemat classes as boring"*
		"*having the practice session and going through the slides"*
		"*Reading the related chapter in the text, the class discussion re given case studies and the youtube videos I watched"*
Self-Satisfaction	What effect did this learning experience have on your confidence or motivation?	***"****I felt more motivated and more confident that I WILL pass hemat this time around."*
		"I was motivated to do further reading as there were still aspects of the topic I did not fully understand"
		"*My confidence is neutral in terms of I'm still taking the time to understand the concepts."*
		"*not much"*

These statements support the mastery/growth pathway of Boekaerts' SRL model (Panadero, 2017). Although one redoer reported being *"bored"* in the environment, he later described he was *"still interested"* in learning the tasks, the second time-around; these comments suggest a level of intrinsic motivation present in this learner (Boekaerts, Zeidner and Pintrich, 1999).

As a collective, the redoers' responses revealed at least one subprocess from each of the three models (Boekaerts, Zeidner and Pintrich, 1999; Pandaero, 2017).

Self-Reporting, Self-Regulating Themes for First Timers' Survey Responses

As noted previously, participants willingly selecting one survey versus the other displays self-judgement (Panadero, 2017). Since the first timers selected both survey types (see Tables 1 & 2), the results are presented based upon the surveys (learnt and did not learn).

When asked what made them perceive learning to be successful at the beginning and at the end of the study, the following responses were noted: *"Being able to remember what I have learnt almost a week ago"*, *"I was able to identify cells confirmed to be correct by others…."* and *"The anxiety I felt when the topics were first introduced has gone and I am more confident in my knowledge".* When asked what they believed was the determinant factor(s) for successfully learning the task, responses such as: *"being relaxed/comfortable"*, *"receiving the teacher's help"*, *"preparing ahead of class"*, *"doing assessments"*, *"using the study guides"* and *"knowing the objectives of the class"* were cited.

A sample of the 14 responses were aligned with the survey item of the specific SRL construct named (see Table 4). Noteworthy points include the absence and uncertainty of strategic planning processes in a few first timers and significant responses either doubting or uncertain about the expectation outcomes for the weekly tasks. The emotional status of these learners was described as being: in a*" good mood"*, "*open-minded, excited and willing to learn…"* in an *"…atmosphere [that] was comfortable for learning";* thus supporting the mastery/growth pathway of Boekaerts' Dual Processing SRL model (Boekaerts, Zeidner and Pintrich, 1999).

For the first timers who did not learn, seven responses were obtained. All seven intended to learn the weekly tasks. When asked if they thought they would learn the weekly task before performing it, the majority affirmed a positive belief. For those that were

Table 4. Analysis of First Timers' Survey Responses for Zimmerman's Model.

SRL Phase	Survey Item	Redoers' Responses
Goal Setting	Did you have the intention to learn this task?	*"Yes"* **(all 14 responses)**
Strategic Planning	Are you making new plans to learn more?	*"Yes"***(11 responses)** *"No"* **(2 responses)** *"I don't know"* **(1 response)**
	What is your next step after this learning experience?	*"I have gone over the characteristics of the different types of cell, trying to know them by heart and relate to what it looks like under the microscope because the words and the picture under microscope can be a bit off."*
		"Watching YouTube videos, read the required text and also other Haematological text books which help in the area"
Intrinsic Motivation	Why did you want to learn this task?	*"I have to learn it in order to pass my course"*
		"to be knowledgeable. I felt I needed to for my sake, my grade sake, work world/internship sake and most importantly for my prospective patients sake"
		"Already have too much notes to catch up on […] I did not want to add more to that to do list"
Outcomes Expectations	Did you believe that you were going to succeed at this task?	*"Yes"* **(7 responses)** *"No"* **(2 responses)** *"I don't know"* **(5 responses)**
Self-Evaluation	What do you think was important in helping you learn this task?	**"***Giving it my undivided attention and allowing myself to get comfortable in what I was doing to enhance my focus"*
		"*Preparing ahead of class, identifying my challenges and creating ways in which I could overcome them"*
		"*Me being relax and not feeling too pressured"*
Self-Satisfaction	What effect did this learning experience have on your confidence or motivation?	*"I was more motivated to tackle the task because it didn't seem as grim as I previously thought. Not as confident in identifying the cells but more motivated to"*
		"I became more confident in this course…"
		"it has definitely motivate me. I want to learn more and become 100% confident"

uncertain beforehand, their reasons for uncertainty included not doing *"…enough reading prior to the class"* and stating, *"It's really complex"*. When asked what made them perceive learning did not occur, most responses noted an inability to perform the tasks during class and others stated they couldn't recall the material after class, or they realized after class they couldn't cover the objectives.

Self-reflections on motivation and/or confidence revealed the majority of first timers who did not learn reported being demotivated (e.g. *"I felt a little demotivated as I've tried but my methods keep going down hill"* or *"I felt like it was just too much and i can't ever get it right"*) or less confident (e.g. "*It affected my confidence in understanding the material"*). The minority stated this experience *"…gave me a hope for gaining a better understanding in order to pass the module"* and they *"…wanted to understand more"*. Most of these first timers identified one facet of the weekly task that was satisfying, except for one learner. Most learners identified follow-up self-regulatory steps they deemed to be corrective, except for one learner. Boekaerts' well-being pathway enables the learner to always protect their ego upon continuous assessment and cognition of a task that threatens it (Panadero, 2017). These less confident and demotivated first timers are at-risk of activating or may activate Boekaerts' well-being pathway (Pandaero, 2017).

As a collective, the first timers' self-reporting self-regulating survey responses revealed the presence of all three SRL phases. Since there were mixed responses regarding the perception of learning, a more detailed analysis is required (in tier two of data collection) to speak to the SRL activities in the first timers.

Quantitative Analysis

2) Which study patterns were revealed by the interviewees' digital footprint and interview responses?

Content analysis and open coding was done to identify evidence of the four qualitative learning patterns as defined by the Inventory of Learning Styles, ILS (Vermunt and Donche, 2017). The participants' digital footprint was triangulated with the content analysis to answer the second research question (Bhattacherjee, 2012).

Therefore, the data was coded into Reproduction-Directed Learning (RDL), Meaning-Directed Learning (MDL), Application-Directed Learning (ADL) and Undirected Learning (UDL) to obtain primary, secondary and tertiary themes (see Appendix I). Primary themes were those seen in all interviewees from both populations, secondary themes were designated to the second-highest occurrence and tertiary/other themes were responses in the minority. In this second tier of data collection, the populations were separated into redoers and first timers to obtain a fulsome picture of participants' study patterns per category. Also included are examples of the supporting quotations made by the interviewees for the significant learning patterns noted in each population (see Appendices K and L).

Learning Patterns of Redoers

The learning patterns of redoers revealed 100% displaying both aspects of self-regulation attributed to MDL pattern (Vermunt and Donche, 2017). More than half (66.7%) of the redoers gave responses aligned with the conceptions of learning and learning orientations for MDL (see Table 5). Both processing strategies represented by MDL were noted in the redoers, but they were represented in the minority of responses (see Appendix K). All six criteria that define the MDL pattern were noted in the redoers (see Appendix I). Other learning patterns observed with some of the redoers included RDL, ADL and UDL. Unlike MDL, the remaining three learning patterns were not represented by all redoers. Additionally, only a few of the criteria that define RDL and UDL learning patterns were noted in the redoers' responses (see Appendix I). Specifically, three out of the seven criteria associated with the RDL pattern and two of the four criteria for UDL patterns were noted (see Appendix I). All the criteria aligned with ADL were seen, but only in the minority of redoers (see Appendix I & Table 5).

Redoers' Digital Footprint

Defined as the unique electronic signature resulting from participant's survey responses and video logins, the digital footprint of the redoers sampled revealed 100% perceived learning took place in the first and second weeks of this intervention with no responses recorded for the final week. For the eight weeks of the intervention, the digital records revealed none of these learners selected the survey focused on the absence of learning, (see Table 6).

Overall, these redoers logged on to Google Forms to access all three videos 17 times for the duration of the study, accounting for 46% of the total logins (see Appendix G for detailed data for each redoer).

Summary of Study Patterns of Redoers.

Defined in this research as participants' learning patterns alongside their digital footprint, the study patterns of these redoers in tier two of data collection revealed learning patterns aligned mostly with MDL and ADL patterns (wherein all characteristics of both patterns were exhibited); the latter was seen in minor quantities (33.3%). Collectively, the redoers displayed a robust digital footprint evidenced more so by the quantity of video logins and type of survey selected, rather than the number of surveys completed.

Table 5. Learning Patterns, Primary and Sub-Themes Recorded from Redoers

Learning Pattern	Primary Themes	Secondary Themes related to the Primary Themes	Other Themes
MDL	Learning Process & Outcomes	Construction of Knowledge	Relating & Structuring
	Learning Contents	Personally Interested	Critical Processing
RDL	_	Memorising & Rehearsing	Learning Process
		Certificate Oriented	_
ADL			Concrete Processing
		_	Vocation Oriented
	_		Use of Knowledge
UDL	_	Ambivalent	Lack of Regulation

Table 6. Data about the Survey Type & Video Logins (Redoers)

Student Identifier	Surveys completed per Week			Video Logins	Comments
	One	Three	Eight		
AS(R)	L	L	-	7	Video logins for all 3 videos
AM(R)	L	-	-	5	Video logins for all 3 videos
SE(R)	L	-	-	5	Video logins for all 3 videos

L, Learnt Survey; R, Redoer

Learning Patterns of First Timers

The study patterns of first timers revealed 100% displaying four criteria the MDL pattern and the remaining criteria of this pattern were exhibited by more than half of this population (see Table 7). All six criteria that define the MDL pattern were noted in the first timers (see Appendix I). Comparable to the MDL pattern, all the UDL criteria were exhibited but unlike the MDL pattern, 66.7% of the population gave responses that aligned with the UDL pattern. Additionally, all three criteria of the ADL pattern were documented with more than half of the first timers giving responses for conceptions of learning and learning orientations respectively. However, only one-third of the population displayed evidence of processing strategies in the ADL pattern. Five of the seven criteria for the RDL pattern were noted in 66.7% of the first timers with one-third of their responses aligned with external regulation and conceptions of learning, respectively (see Table 7).

First Timers' Digital Footprint

There were survey responses collected from all three weeks of data collection for the first timers. Most perceived learning occurred in the first week, but 33.3% stated otherwise. However, the responses obtained decreased throughout the survey, such that two responded in the third week and one in the final week (see Table 8). Equal numbers of first timers gave opposing perceptions regarding learning in the third week. The lone respondent indicated learning occurred in the final week.

For the eight weeks of the intervention, the digital records revealed one participant completed all three surveys and a total of two-thirds of the first timers selected the TSRQ focused on the absence of learning, (see Table 8).

Overall, the first timers logged on to Google Forms to access two of the three videos four times for the duration of the study, accounting for 11% of the total video logins. The digital records reveal the third video was not accessed by any first timer (see Appendix G for detailed data for each first timer).

Summary of Study Patterns of First Timers.

The study patterns of the first timers in tier two of data collection revealed learning patterns aligned mostly with MDL, UDL and ADL patterns (wherein all characteristics of these patterns were exhibited). Collectively, the first timers displayed a less-than-robust digital

footprint evidenced by their video logins and the type of surveys completed, rather than the quantity completed.

Table 7. Learning Patterns, Primary and Sub-Themes Recorded from First Timers

Learning Pattern	Primary Themes	Secondary Themes related to the Primary Themes	Other Themes
MDL	Learning Process & Outcomes	Construction of Knowledge	
	Learning Contents	Critical Processing	_
	Relating & Structuring		
	Personally Interested		
RDL	_	Memorising & Rehearsing	Learning Outcomes
		Analysing	Intake of Knowledge
		Certificate Oriented	
ADL	_	Use of Knowledge	Concrete Processing
		Vocation Oriented	
UDL	_	Lack of Regulation	_
		Stimulating Education	
		Cooperative Learning	
		Ambivalent	

Table 8. Data about the Survey Type & Video Logins – First Timers

Student Identifier	Surveys completed per Week			Video Logins	Comments
	One	Three	Eight		
SB(F)	L	D	L	1	Logins for Video 1
MI(F)	D	L	-	0	No Logins recorded
SA(F)	L	-	-	3	Logins for videos 1 & 2

L, Learnt Survey; D, Did Not Learn Survey; F, First timer

Discussion & Conclusions

This research assessed the preparatory and self-appraisal phases of SRL in Haematology 2 Practical redoers and first timers. Since SRL assessment was offline, the adapted survey required learners to metacognitvely assess their performance and provide responses to the task based SRL survey items. As such the performance phase of SRL was not directly assessed.

For both sets of learners, the 23 to 26-item surveys revealed a wide range of subprocesses from the two SRL phases assessed. Pintrich's emphasis on cognition regulation was a focal point of this study as the multiple distribution of SRL surveys engaged participants in the willful and *"purposive personal processes"* to determine whether learning occurred (Boekaerts, Zeidner and Pintrich, 1999, p. 17). From this purposeful action, participants engaged their SRL skills to become active participants in their learning process (Puustinen and Pulkkinen, 2001). Thereafter influence of Zimmerman's and Boekaerts' SRL models were used to bring learners' awareness to what motivates their learning alongside when and where learning occurred. Evidence of task analysis, self-motivation, self-judgement and self-reactions were noted in both cohorts (see Tables 3 and 4).

The difference between redoers and first timers regarding perception of learning is noteworthy, but the limitations faced with the accuracy of SRL self-reports (Winne, 2010) necessitates an unbiased assessment of learning such as learners' academic performance. Indeed, cognizant of this limitation Colthorpe et al (2015) included digital traces to support the self-reports used in their research. Similarly, this effort included digital support to promote development of SRL and learning of the task. Learning was facilitated by video recordings of study guides that used imagery to help learners convert visual and auditory data to mental notes (Boekaerts, Zeidner and Pintrich, 1999) to be used by learners later for recall in their face-to-face sessions. To bolster the self-reports used in this study, semi-structured interviews were also included (as a means of multi modal sources of data (Ben-Eliyahu and Bernacki, 2015 as cited by Colthorpe et al, 2015). One such interviewee shared the impact of the video tutorials applied to her face-to-face sessions: "*... for instance…so using the descriptions that you gave in your videos…like, it really helped because…like for instance you said Eosinophils had the orange granules…so you will have a mental note of that and when you're looking at the slides [microscopically] you'll say – this is what Mrs. Munroe was talking about…so incorporating the different styles, it really helps*". The video tutorials were also created to promote aspects of task strategies from the performance phase of

Zimmerman's cyclical SRL model, whereby the complex learning task was dissected into its components and re-built into problem-solving items (Boekaerts, Zeidner and Pintrich, 1999). However, the conceptual scaffold appears to not completely fulfil all criteria of task strategies as one learner shared *"I like the way you did it, I am going to be honest, but just to put in a bit of life…real-life situations…. but just some real-life situations …I don't know how to bring that across, but just to compare it something familiar…something we can tie to understand it more…".* The tool appeared to lack the ability to help this learner re-organize the information shared in a meaningful way (Boekaerts, Zeidner and Pintrich, 1999), however the learner appears aware of how she learns effectively hence this feedback can be used in future iterations of this action research-based tool (Ary et al, 2014).

The research objectives of assessing and promoting SRL were achieved, on the proviso that response bias was not present (Valle and Nunez, 2008). The research questions were answered and revealed a baseline level of SRL skills in both learner cohorts.

As an aside, to assess the baseline levels of SRL skills in learners versus their development throughout the study, six participants (five first timers and one redoer) completed at least two of the three possible surveys. Although not a focal point of this study, noteworthy is the observation in one participant who responded on all three surveys. In the first week, she states the reasons for perceived learning was understanding a specific item for the weekly task, e.g. "*finding how the chemical stains actually work and what they stain [..] will help me identify whatever I'm looking for"*. Reviewing the responses to the same questions in the final week, her response changes to a broader appreciation of learning the weekly task, e.g. *"knowing the objective under this topic […] helps you focus on the points given."* This observation suggests a deeper appreciation of SRL in this task for this participant, wherein learning is facilitated by the learner (Colthorpe et al, 2015).

As mentioned previously, the self-reports of redoers and first timers were used alongside interview responses to better understand the study patterns in representatives from both cohorts. Learners' digital footprints were used as a traceable method of engaging participants and observing (from a distance) their use of the learning material. Learners' digital footprints in this study was influenced by the traces internet users leave (TED, 2014), but the concept was modified to assess the type of survey, number of survey responses and video logins. The robustness of a learners' digital footprint was further defined by whether the 'learnt' survey was chosen over its opposite and the number of video logins.

The redoer collective left a complete digital footprint that was robust based upon their survey responses and video logins, whereas most first timers left a complete digital footprint and the comparatively less robust digital traces were defined based upon the admixture of survey responses and reduced number of video logins (see Tables 6 and 8). A noteworthy observation with the tinker used to upload the video tutorials, is traces were only possible if participants logged their unique identifier in Google Forms. In two cases, (a redoer and first timer) digital traces did not show evidence of video logins but their survey responses (that required participant feedback on the videos) revealed their feedback on the videos (see online repository, weeks 7 and 14 Microsoft Excel data sets – participants TA(R) and MI). This observation reveals a reliance on the learner (by the researcher) for digital traces to be detected. Future iterations of this work will require a tinker that reliably tracks participants use.

The interview responses for both cohorts revealed evidence of meaning-directed and application directed learning in the redoers (see Table 5). As the learning patterns associated with learning that situates the content taught into the greater whole with specific meaning assigned for purposeful use in a vocation (Vermunt and Vermetten, 2004), this group of students displayed features of learning that align with lifelong learning (Aviram et al, 2008). A similar observation was noted with the first timers (see Table 7), however akin to their less-than-robust digital footprint there was the observation of traits associated with undirected learning. According to Vermunt and Donche (2017) the learning patterns model is influenced by factors such as personal and contextual factors (see Figure 1). The observation of undirected learning could be a feature of the age, knowledge of subject matter and educational experience of these learners (personal factors), wherein the contextual factors (related to teaching methods used, types of assessments given and opportunities to collaborate with students) were kept constant (independent variable) for both redoers and first timers. Therefore, the difference in learning patterns noted could be attributed to the specific learner group (Vermunt and Donche, 2017).

The study patterns noted in these two cohorts align with the literature (Vermunt and Vermetten, 2004), the relevance of which to this classroom issue can be realised in putting supportive measures in place to foster meaning-directed and application directed in both learner types. The *status quo* of teaching both learner types without considering their baseline level of SRL or the impact personal factors have on learning patterns promises a continuation of the *status quo*. Suggestions for implementation include targeted SRL activities incorporated within assessments to have a grade assigned to these metalearning activities

(Colthorpe et al, 2015). Targeted SRL activities must explicitly bring learners' awareness to developing hierarchical process goals to build self-efficacy, promote self-observation, self-evaluations and promote the mastery pathway of growth development (Boekaerts, Zeidner and Pintrich, 1999; Panadero, 2017). Also recommended are student study strategies such as note taking, reading for comprehension, performance strategies such as writing techniques and problem-solving (Boekaerts, Zeidner and Pintrich, 1999) to promote traditional learning strategies in these digital users. Moving the focus away from learners and towards the contextual factors referred by Vermunt and Donche (2017), with the presence of educational stakeholders with varying digital literacy, the contextual factors that contribute to friction must also be considered. Where teachers SRL expectations of tertiary students' SRL abilities are not equivalent, the dissonance creates a divide that prevents learning. As one learner shared, *"What I do realize when you're learning, you don't know exactly at what point you're learning…because you think you understand something and then if you should ask a question…"*. This observation aligns with Evensen, Salisbury-Glennon and Glenn's (2001) assertion that curricula nowadays often require learners to be self-regulated, but their structure often opposes the development of positive self-regulation in learners.

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Appendix A

University of Tartu's Introductory Letter to UTech, Ja

Tartu, 30 January 2020

Dr. Janet Campbell-Shelly,
Dean - College of Health Sciences
University of Technology, Jamaica

With the present letter I certify that Primla Williamson-Munroe has drafted a proposal for an action research study concerning task-based self-regulation for WBC identification (using a worded problem study guide) for a subset of Medical Technology students at your institution as part of her Master thesis work in the Master's programme in Educational Technology at the University of Tartu (Estonia). A draft of her proposal will be forwarded for your perusal.

Your consideration in permitting her access to perform this study would be greatly appreciated by all concerned.

Kind regards,
Emanuele Bardone, PhD
Director of the MA Programme in Educational Technology
Centre for Educational Technology
Institute of Education
University of Tartu,
Estonia
Email: bardone@ut.ee

C: Dr. Vanessa White-Barrow, Head of School – School of Allied Health & Wellness

Mrs. Nellian Hutton-Rose, Programme Director – Medical Technology

Appendix B

Informed Consent Form

Title: Action Research promoting WBC Identification Skills & Student Self-Regulation

Student Name & Address: Primla Williamson-Munroe (Student), Master of Arts (MA) in Educational Technology, University of Tartu (UT), Estonia

Phone: (876) 817-2538 Email: pmunroe8@gmail.com

The information provided on this form is presented to you in order to fulfil legal and ethical requirements at the University of Technology, Jamaica (UTech, Ja) for collecting information. The purpose of this form is to allow your students to participate in this intervention. By using Google Forms, I aim to provide external assistance to your students via a copyrighted study guide of my creation and questions that promote self-regulation. Also, this action research aims to enhance student skills in the main topic associated with failures for the last five years in Haematology 2 Practical, MET3012 (WBC Identification). Using Google Forms, the guide and metacognition questions will be given to the students three times (3) throughout the period stated below. Students will use the study guide at their convenience and answer the questions outside of class. Except for one face-to-face session to introduce the project, I will not interact with your students. Data collection for this project includes collection of student responses for the questions to assess students' own perception of learning WBC Identification. As an added feature to this project, student grades on this topic will be used as an objective assessment of student learning. Also, to reduce bias my interactions with you aims to maintain your usual teaching schedule (without interruption), so that any effect of this intervention can be determined through the students' responses and grades. This intervention aims to determine what students think about their learning of WBC Identification along with providing a study guide to enhance their learning process. The potential benefit of this observation includes enhancing student skills in this complex learning task.

All data will be gathered during the weeks of February 24th to April 13th, 2020.

1. Participation is voluntary. There is no penalty for refusal to participate or withdrawal.
2. There are no risks to the persons who participate. Participants' confidentiality will be protected, since data collection requires identification numbers and email addresses only.
3. My interaction is limited to student responses to prepared online questions (no dialogue).
4. There are three (3) boxes at the end of this form, please select (2) of them.
5. Selecting the first box indicates you have been informed about the research conditions.
6. If you are willing to participate, select the box below that indicates your consent.
7. If you do not want to participate, select the box that declines participation.

- ☐ I have read the information provided and understand the terms outlined.
- ☐ I have read the information provided and **agree** to participate.
- ☐ I have read the information provided but **do not agree** to participate.

_____ _____

Classroom Manager/Module Leader Date

_____ _____

Dean, College of Health Sciences Date

_____ _____

Primla Williamson-Munroe (MA Student) Date

Appendix B

Informed Consent Form

Title: Action Research promoting WBC Identification Skills & Student Self-Regulation

Student Name & Address: Primla Williamson-Munroe (Student), Master of Arts (MA) in Educational Technology, University of Tartu (UT), Estonia

Phone: (876) 817-2538 Email: pmunroe8@gmail.com

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The purpose of this form is to allow your students to participate in this intervention. By using Google Forms, I aim to provide external assistance to your students via a copyrighted study guide of my creation and questions that promote self-regulation. Also, this action research aims to enhance student skills in the main topic associated with failures for the last five years in Haematology 2 Practical, MET3012 (WBC Identification). Using Google Forms, the guide and metacognition questions will be given to the students three times (3) throughout the period stated below. Students will use the study guide at their convenience and answer the questions outside of class. Except for one face-to-face session to introduce the project, I will not interact with your students. Data collection for this project includes collection of student responses for the questions to assess students' own perception of learning WBC Identification. As an added feature to this project, student grades on this topic will be used as an objective assessment of student learning. Also, to reduce bias my interactions with you aims to maintain your usual teaching schedule (without interruption), so that any effect of this intervention can be determined through the students' responses and grades. This intervention aims to determine what students think about their learning of WBC Identification along with providing a study guide to enhance their learning process. The potential benefit of this observation includes enhancing student skills in this complex learning task.

All data will be gathered during the weeks of February 10th to April 13th, 2020.

1. Participation is voluntary. There is no penalty for refusal to participate or withdrawal.
2. There are no risks to the persons who participate. Participants' confidentiality will be protected, since data collection requires identification numbers and email addresses only.
3. My interaction is limited to student responses to prepared online questions (no dialogue).
4. There are three (3) boxes at the end of this form, please select (2) of them.
5. Selecting the first box indicates you have been informed about the research conditions.
6. If you are willing to participate, select the box below that indicates your consent.
7. If you do not want to participate, select the box that declines participation.

☑ I have read the information provided and understand the terms outlined.

☑ I have read the information provided and **agree** to participate.

☐ I have read the information provided but **do not agree** to participate.

Classroom Manager/Module Leader — Date: 24/02/2020

Dean, College of Health Sciences — Date: 25/2/2020

Primla Williamson-Munroe (MA Student) — Date: 2020/02/24

Appendix C

Offline Task-Based Self-Regulation Questionnaire (TSRQ)

Answer these questions if you thought you LEARNT this week's task.

1. Please enter your UTech, Ja identification number. _____
2. What did you learn this week? _____
3. Describe where learning took place. _____
   (Hint: Think about the place, time, presence of others, your mood etc..)
4. Did you have the intention to learn this task? Yes No
5. Did you try more than one way to learn during the learning process? Yes No
6. If Yes to question 5, please give examples of the things you tried. _____
7. Why did you want to learn this task? _____
8. Did you believe that you were going to succeed at this task?
   Yes No I do not know
9. What do you think was important in helping you learn this task?_____
10. Why did you choose the strategy mentioned in question 9? _____
11. What made you aware that you were successful in learning this task?_____
12. Do you think additional assistance was required for this task? Yes/No/I do not know
13. If Yes to question 12, say who the assistance you require should come from. ____
14. Did you ask for help from the Teacher? Yes No
15. Did you ask for help from a fellow student? Yes No
16. What effect did this learning experience have on your confidence or motivation?_
17. What aspects of this learning experience did you think were satisfying? _____
18. What is your next step after this learning experience? _____
19. Are you making new plans to learn more? Yes No I do not know
20. Have you done this task before, in a previous academic year? Yes No
21. If Yes to question 20, say how you feel about it now compared to the first time you did it. _____
22. If there is anything you would **add or remove** from the WBC Study guide used, please share your thoughts here._____

Thank You!

Answer these questions if you thought you did NOT LEARN this week's task.

1. Please enter your UTech, Ja identification number. _____
2. What was the task to be learnt this week? _____
3. Did you have the intention to learn this task? Yes No
4. If No, please state why. _____
5. Why do you think it didn't work out? _____
6. Why did you attempt this task? _____
7. Did you believe that you were going to succeed? Yes No I do not know
8. If you **didn't choose** Yes to question 7, please state why. _____
9. Did you try more than one way to learn during the learning process? Yes No
10. If No to question 9, please state why. _____
11. Do you think additional assistance was required for this task? Yes/No/I do not know
12. If Yes to question 11, say who the assistance you require should come from. ____
13. Did you ask for help from the Teacher? Yes No
14. If No to question 13, please state why. _____
15. Did you ask for help from a fellow student? Yes No
16. If No to question 15, please state why. _____
17. How did you come to realize that you did not learn this task? _____
18. What effect did this learning experience have on your confidence or motivation?_
19. What aspects of this learning experience did you think were satisfying? _____
20. What is your next step after this experience? _____
21. Are you making new plans to learn this task? Yes No
22. If Yes to question 21, what do you plan to do? _____
23. If No to question 21, please state why. _____
24. Have you done this task before, in a previous academic year? Yes No
25. If Yes to question 24, say how you feel about it now compared to the first time you did it.

    _____
26. If there is anything you would **add or remove** from the WBC Study guide used, please share your thoughts here._____

Thank You!

Appendix D

Endedijk et al's (2006) Offline Task-Based Self-Regulation Questionnaire (TSRQ)

A questionnaire called "week report" was developed in which student teachers could describe a specific learning experience and the corresponding regulation activities.
The instruction asked the student…to answer every question, but if some questions turned out to be irrelevant for their learning experience they could skip them.

1. What did you learn?
2. In what context did the learning take place (think about place, time, presence of others, your mood etc.)?
3. Did you have the intention to learn this? Did you change your plans during the learning process?
4. Why did you want to learn this? Did you have the feeling that you were going to succeed?
5. How did you do it? Why did you choose this strategy?
6. From whom did you receive or miss help during this learning experiences? Did you ask for help?
7. How did you come to realize you learned something?
8. What kind of effect did this learning experience have on your confidence or motivation?
9. What elements in this learning experience did you experience as satisfying? What would you change the next time?
10. How will you proceed with this (learning) experience? Are you making new plans?

"It was possible to describe a successful or less successful learning experience, for example when learning was planned, but did not take place." (Endedijk et al. 2006, p. 14). To determine a less than successful learning experience, students would answer the following questions instead of the first two questions above:

1. What did you want to learn?
2. Why didn't it work out the way you expected?

Appendix E

WBC Identification Study Guide

Instructions for Using this Study Guide

1) This study guide is comprised of Laws and Rules as determined from my clinical and teaching practice and is specific for the Wright's stained peripheral blood smear. As coined here, these laws and rules do not readily exist in texts or clinical practice.

2) These Laws and Rules are specific for Normal WBCs and the purpose of this research study. The purpose of this guide is for the user to know the laws and rules and apply them as algorithms in solving the Worded Problems that follow. The Laws and Rules in this guide are not meant to be rote memorized, as doing so will not be relevant in your classes our your future clinical practice. These Laws and Rules aim to streamline the process of WBC Identification into a generalizable, logical exercise where the exceptions to the rules can be identified and the user can seek solutions after performing exclusion analysis.

   Intimate knowledge of WBC morphology is needed to proceed with this WBC study guide. **Teaching WBC morphology is out of the scope of this WBC study guide**.

3) Carefully review all Laws and Rules stated herein.

4) Use all Laws, the relevant Rules and your knowledge of WBC morphology to read & understand the Worded Problems that follow.

1ST LAW: ASSESS THE NUCLEUS COLOUR.

COLOUR INTENSITY = NUCLEAR CONDENSATION

Possibilities seen in WBCs:

i. Overall Dark purple colour & darker areas within = C**ondensed**.
ii. Overall dark purple colour = C**ondensed**.
iii. Overall light purple/pink colour & dark areas within = **Fine Condensation Pattern or Condensing**.
iv. Dark purple areas within & Nucleoli = **Immature, but it is Condensing**.
v. Overall pink/purple colour & Nucleoli = **Immature**.
vi. Purple-black colour = **Pyknotic/Dead Nucleus**.

2ND LAW: ASSESS THE NUCLEUS SHAPE.

SHAPE

Possibilities seen in WBCs:

i. Segmented = **Polymorphonuclear** (≥ 2 lobes, but ≤ 5 lobes)
ii. Whole/Round = **Mononuclear** (Indented versus Completely Round)
iii. Unsegmented & not Round/Whole = Look at the nuclear condensation pattern; cell could be a maturation stage (?**Maturing).**

3RD LAW: ASSESS THE NUCLEUS SIZE.

APPROXIMATE SIZE ≡ N:C Ratio

Possibilities seen in WBCs:

i. 1:1 N:C ratio = **Same amount of Nucleus to Cytoplasm.**
ii. ↑ N:C ratio = **More amount of Nucleus to Cytoplasm.**
iii. ↓ N:C ratio = **Less amount of Nucleus to Cytoplasm.**

4TH LAW: KNOW THE CYTOPLASMIC DESCRIPTIONS.

Possibilities seen in WBCs:

i. COLOUR – Pink/Grey/Blue/Blue-Purple/Clear?
ii. SHAPE – Round or Irregular?
iii. CONTENTS & THEIR COLOUR
– Granular or Agranular?
– Vacuoles or NOT?
iv. APPROXIMATE SIZE – N:C Ratio?

Rules for WBCs seen in Normal PB

Rule #1: All laws must be used to identify all normal WBC, never one!

Rule #2: The nucleus of one WBC will either be Polymorphonuclear or Mononuclear, never both!

Rule #3: Normal, mature lymphocytes are never Polymorphonuclear.

Rule #4: Normal, mature granulocytes are never Mononuclear.

Rule #5: The Monocyte is the largest, normal WBC in normal PB.

Rule #6: The small lymphocytes' **nucleus** is the same size as a normal RBC.

Rule #7: Normal Granulocytes' granule sizes (colour) =
Basophil (blue/black) > Eosinophil (orange) > Neutrophil (purple).

Rule #8: The only WBCs that do not have granules are the small & intermediate-sized
Lymphocytes.

Rule #9: The only NORMAL lymphocyte that has granules is the large lymphocyte.
Exception to the rule: some versions of large
lymphocytes may not have granules.

Rules for WBCs seen in Normal PB
(continued)

Rule #10: Although lymphoid cells can have cytoplasms with various shapes, only Lymphocytes are likely to have round cytoplasm's.

Rule #11: Normal WBCs can have different
versions of themselves,
e.g. A) Large lymphocytes can possess granules and some may not.

B) Monocytes tend to be mononuclear,
but some may be polymorphonuclear.

Rule #12: If you cannot readily identify a nucelated cell, use the first law to determine
if the cell is mature.
If it is, then exclude all the mature cells it CANNOT be, then see what remains (this is
called exclusion analysis).

Worded Problems: Basic Level

1) What is the difference between saying: "normal WBCs seen in PB" and "WBCs seen in normal PB"?

2) How many normal, mature WBCs have granules?
   a) Name them.
   b) Use the 4th law to differentiate these WBCs.
   c) Use the remaining laws to differentiate them.

3) Which cell line has Polymorphonuclear cells?

4) Which cell line tends to have Mononuclear cells?

5) How many normal WBCs have a decreased N:C ratio?
   a) Name them.
   b) Use the 4th law to differentiate these WBCs from each other.
   c) Use the remaining laws to differentiate them.

6) How many normal WBCs in PB do not & will never have vacuoles?
   a) Name them.
   b) Use the 4th law to differentiate them.
   c) Use the remaining laws to differentiate them from each other.

Worded Problems: Advanced Level

7) This cell is A normal, mature WBC with decreased N:C Ratio, has granules and an irregularly-shaped cytoplasm.
   a) Which cells can be excluded from this description?
   b) Of the cells that remain, use the relevant laws to differentiate them from each other.
   c) Can you definitively identify which normal WBC is present from the description given?

8) A large cell has granules, a 1:1 N:C ratio, has an irregularly shaped cytoplasm and condensed nuclear chromatin pattern.
   a) Which cells can be excluded from this description?
   b) Of the cells that remain, use the relevant laws to justify why they cannot be the cell described.
   c) Identify which normal WBC could be the one(s) being described here.

9) This normal WBC has an increased N:C ratio, irregular-shaped cytoplasm with an indented nucleus.
   a) Which cells can be excluded from this description?
   b) Justify your response.
   c) Of the cell(s) that remain, use the relevant laws to justify why they match the description given.
   d) For the cell(s) suspected, do you expect it to have granules?

10) A normal WBC seen in normal PB has vacuoles, granules, an irregularly-shaped cytoplasm & is large.
   a) Give one example each of a myeloid and lymphoid cell that matches this description.
   b) Which law(s) will help differentiate these cells from each other?
   c) Give two features that will definitively differentiate these two large cells from each other.

Disclaimer

The information provided herein has been created from personal clinical practice and almost two decades of teaching practice, along with information from multiple undergraduate textbooks (especially Harmening, 2009).

The Laws and Rules as described herein are accurate, but do not appear anywhere in literature as termed; although they are factual they have been collected and gathered into discrete points, specifically for this action research intervention.

You may use these Laws and Rules as intended (as a WBC study guide), but they cannot replace class attendance or reading the teacher-assigned Haematology-related material.

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This literary work was created using Microsoft PowerPoint & Google Forms templates with Zoom & YouTube platforms.

Appendix F

Semi-Structured Interview Questions

1) What study techniques supported your learning?

2) What study techniques didn't support your learning?

3) What (if anything) did you find useful about the videos for helping WBC identification?
    a. Why was this thing you noted helpful for you?
    b. If the videos were **not** helpful, please give suggestions to improve them for how best you learn.

4) How did this learning experience support your development as a learner – did you learn something about yourself as a learner?
    a. If so, please elaborate.
    b. Please say how this thing you learnt about yourself can be used in your future studies.

5) How would you describe your learning experience this year compared to the first time you attempted this subject?

6) What do you do when you believe you learnt a topic but your grades reflect otherwise?

7) Based upon your experience, what are other ways teaching WBC Identification can be enhanced?

8) How do you think these suggestions you made about improving the teaching of this complex task would impact your weekly timetable?

Appendix G

Tier One Data Collection revealed Digital Footprint of 16 Participants.

#	Initials	TSRQ Week#		Video Access 1/2/3 (#)	Comments First timer (F) Redoer (R)
		LEARNT	DID NOT LEARN		
01	SB(F)	1 & 8	3	**1/0/0**	F
05	CB(F)	1	_	**2/0/0**	F
06	SE(R)	3	_	**2/2/1**	R
09	JP(F)	1	_	**1/0/0**	F
14	PM(F)	1 & 8	3	**0/1/0**	F
17	AS(R)	1 & 3	_	**3/3/1**	R
18	MM(R)	1	_	**2/1/0**	R
19	SA(F)	1	_	**2/1/0**	F
22	DCa(F)	1	_	**1/0/0**	F
23	DCh(F)	1	3	**1/1/1**	F ((male)
24	AM(R)	1	_	**1/1/3**	R
26	MI(F)	3	1	**0/0/0**	F (TSRQ & interview reveal videos watched)
27	KD(F)(F)	8	_	**1/0/3**	F
28	ST	_	1 & 3	**1/1/0**	F
30	KR(R)	3	_	**1/1/1**	R (male)
36	DW(F)	1	_	**1/0/0**	F

Appendix H

Learning Components, Scales and a Description of their content for the Inventory of Learning Styles, ILS (from Vermunt and Vermetten, 2004).

Learning Components & their Descriptions	
Scales of the ILS	Description of Content
PROCESSING STRATEGIES	
Deep Processing	
Relating and Structuring	Relating elements of the subject matter to each other and to prior knowledge; structuring these elements into a whole.
Critical Processing	Forming one's own view on the subjects that are dealt with, drawing one's own conclusions, and being critical of the conclusions drawn by textbook authors and teachers.
Stepwise Processing	
Memorizing and Rehearsing	Learning facts, definitions, lists of characteristics, and the like by heart by rehearsing them.
Analysing	Going through the subject matter in a stepwise fashion and studying the separate elements thoroughly, in detail and one by one.
Concrete Processing	Concretising and applying subject matter by connectting it to one's own experiences and by using in practice what one learns in a course.
REGULATION STRATEGIES	
Self-Regulation	
Learning Process and Outcomes	Regulating one's own learning processes through regulation activities like planning learning activities, monitoring progress, diagnosing problems, testing one's outcomes, adjusting and reflecting.
Learning Contents	Consulting literature and sources outside the syllabus.
External Regulation	
Learning Process	Letting one's own learning process be regulated by external sources, such as introductions, learning objectives, directions, questions or assignments of teachers or textbook authors.
Learning Outcomes	Testing one's learning outcomes by external means, such as tests, assignments and questions provided.
Lack of Regulation	Monitoring difficulties with the regulation of one's own learning processes.
CONCEPTIONS OF LEARNING	
Construction of Knowledge	Learning viewed as constructing one's own knowledge and insights. Most learning activities are seen as tasks of students.
Intake of Knowledge	Learning viewed as taking in knowledge provided by education through memorizing and reproducing; other leaning activities are tasks of teachers.
Use of Knowledge	Learning viewed as acquiring knowledge that can be used by means of concretising and applying. These activities are seen as tasks of both students and teachers.
Stimulating Education	Learning activities are viewed as tasks of students, but teachers and textbook authors should continuously stimulate students to use these activities.
Cooperative Learning	Attaching a lot of values to learning in co-operation with fellow students and sharing the tasks of learning with them.
LEARNING ORIENTATIONS	
Personally Interested	Studying out of interest in the course subjects and to develop oneself as a person.
Certificate Oriented	Striving for high study achievements; studying to pass examinations and to obtain certificates, credit points and a degree.
Self-test Oriented	Studying to test one's own capabilities and to prove to oneself and others that one is able to cope with the demands of higher education.
Vocation Oriented	Studying to acquire professional skill and to obtain a(nother) job.
Ambivalent	A doubtful, uncertain attitude toward the studies, one's own capabilities, the chosen subject area, the type of education, etc.

Appendix I

Characteristics of The Four Qualitative Learning Patterns – their Domains and Scales (from Vermunt and Vermetten, 2004).

Undirected Learning (UDL)	Reproduction-Directed Learning (RDL)	Meaning-Directed Learning (MDL)	Application-Directed Learning (ADL)
_	**Stepwise Processing** 1. Memorising &. Rehearsing 2. Analysing	**Deep Processing** 1. Relating & Structuring 2. Critical Processing	1. **Concrete Processing**
1. **Lack of Regulation**	**External Regulation** 3. Learning Processes 4. Learning Outcomes	**Self-Regulation** 3. Learning Process & Learning Outcomes 4. Learning Contents	**Self-Regulation** & **External Regulation** variants of this learning pattern exist.
Conceptions of Learning 2. Stimulating Education 3. Cooperative Learning	**Conceptions of Learning** 5. Intake of Knowledge	**Conceptions of Learning** 5. Construction of Knowledge	**Conceptions of Learning** 2. Use of Knowledge
Learning Orientations 4. Ambivalent	**Learning Orientations** 6. Certificate Oriented 7. Self-test Oriented	**Learning Orientations** 6. Personally Interested	**Learning Orientations** 3. Vocation Oriented

Number of Characteristics/Criteria per Learning Pattern: RDL = 7 ; MDL = 6; ADL = 3 and UDL = 4.

Appendix J

Initial Themes from Participants' Interviews

AS(R)	AM(R)	SE(R)	MI(F)	SB(F)	SA(F)
SR: Learning Contents	SR: Learning Contents	SP: Memorising & Rehearsing	SR: Learning Process & Outcomes	SR: Learning Contents	SR: Learning Contents
COL: Construction of Knowledge	COL: Use of Knowledge	SR: Learning Contents	SR: Learning Contents	COL: Stimulating Education	DP: Relating & Structuring
SR: Learning Process & Outcomes	SP: Memorising & Rehearsing	Concrete Processing	SP: Memorising & Rehearsing	SR: Learning Process & Outcomes	COL: Use of Knowledge
LO: Vocation Oriented	LO: Certificate Oriented	COL: Construction of Knowledge	LO: Ambivalent	DP: Critical Processing	SR: Learning Process & Outcomes
DP: Relating & Structuring	LO: Personally Interested	LO: Ambivalent	Lack of Regulation	SP: Memorising & Rehearsing	COL: Stimulating Education
	DP: Critical Processing	SR: Learning Process & Outcomes	DP: Relating & Structuring	LO: Personally Interested	DP: Critical Processing
	SR: Learning Process & Outcomes	ER: Learning Process	LO: Certificate Oriented	LO: Vocation Oriented	LO: Personally Interested
	LO: Ambivalent	LO: Certificate Oriented	LO: Vocation Oriented	SP: Analysing	COL: Cooperative Learning
		LO: Personally Interested	COL: Construction of Knowledge	COL: Cooperative Learning	SP: Analysing
		Lack of Regulation	LO: Personally Interested	COL: Construction of Knowledge	LO: Certificate Oriented
			Concrete Processing	DP: Relating & Structuring	LO: Ambivalent
			COL: Use of Knowledge		Lack of Regulation
					ER: Learning Outcomes
					COL: Intake of Knowledge

SR: Self-Regulation; COL, Conceptions of Learning; LO, Learning Orientations; SP, Stepwise Processing; DP, Deep Processing; ER, External Regulation

Appendix K

Learning Patterns, Primary Themes and Sub-Themes with Supporting Quotations from Redoers

For MDL Pattern

Primary Themes - Learning Process & Outcomes

"Well, I have to sacrifice some sleep, of course and sometimes I don't get to touch on as much as I would like to. The thing is I remember a lot from class, and I make little jottings, so sometimes (even without reviewing something, the notes that I make) I can remember what the Teacher says. But in order to pack (I'm not sure I am doing a good job of explaining it, but) in order to……whatever the teacher is saying, I have to read additional sources. I have to really read it myself or watch a video to understand exactly what they're saying and have like excess information in the event I am asked to write about it or something like that…" AS(R)

"It would work out good, because going into a new course of study I would have known what works for me and what doesn't work. So even if (you know like) the timetable is more hectic, it would still (you know) somewhat give me…..(what's the word to say?)…like an edge (basically) with how to manage myself." AM(R)

"Well, I mean once it's available whenever I have the time to look at it…I mean if it's going to be a scheduled thing, then it probably wouldn't work, but if it's available at any time and say I know that I need the help…so I would make the time to view the material for it to help me…as often as I possibly can." SE(R)

Primary Themes – Learning Contents

"I don't think that there's anything that doesn't help. It's just that there's no one thing alone; it's a combination of methods or techniques. I can't just rely on one thing. I have to use more than one sources. I have to read the theory. I have to probably watch a video and I have to definitely listen to what the Teacher does in class." AS(R)

"And when I realized (like) watching videos and studying beforehand really helped." AM(R)

"…..if I had only used the text to help me with WBC Identification I wouldn't be as comfortable as I am now…" SE(R)

Secondary Themes – Construction of Knowledge

"Yes, it is….and maybe it's a preference, but I don't like using one source. I feel like the more I can gather from different sources, the better it is for me." AS(R)

"…apply what I already know about myself to help me with the module." SE(R)

Secondary Themes – Personally Interested

"Ok, before the semester started I knew that I wanted to pass…..[be]cause it was Haematology I was aiming to just pass….like something in the 50s…I'm good with that, I just want to pass. But with the intervention I realised I can actually get a really good grade…so it shifted from just wanting to pass to wanting to get like an 'A' or (you know even) probably like a 'B'." AM(R)

"When I started to see some improvement, I started to feel a little bit more confident and I also wanted to work harder so that I could get better at it." SE(R)

Other Themes – Relating and Structuring
"…because I am more familiar with the content but this time around, I can see why I failed the first time. " AS(R)

Other Themes – Critical Processing

"That's the thing…you use more than one source." A M(R)

For ADL Pattern

Other Themes – Concrete Processing

"„„because the explanations given by the study guides as well as me being able to apply that in practice sessions made the whole WBC differentiation somewhat easier." SE(R)

Other Themes – Vocation Oriented

" I'm just not sure what field I'd like to go in as yet or if I'd like to cross over into something related to it. I'm not sure what I'd like to do further on. I know I'd like to use the Med.Tech. degree as a foundation for whatever it is I am moving on to." AS(R)

Other Themes – Use of Knowledge

"…so using the descriptions that you gave in your videos…like, it really helped because…like for instance you said Eosinophils had the orange granules…" AM(R)

Appendix L

Learning Patterns, Primary Themes and Sub-Themes with Supporting Quotations from First Timers

For MDL Pattern

Primary Themes - Learning Process & Outcomes

"…I am coming from work heading off to class I could always pull up the video (using the app or go on to the website, because I can access it from my phone as well) and listen to that video or watch that video on my way to class…so even if it's not played in class and we have to do it our own, the time I am taking to come or to go to school, that is, in that time I could go over the video, watch the video…" MI(F)

"I could apply it, but it has to be a course that require a lot of heavy reading…you know some courses you come by, you read it one time, you understand it…but Haematology…WBCs, they are so similar with clinical manifestation and lab results, you have to like, literally read it and like indulge in it and like fully understand it…so the work is required for this area….but like for other courses, I wouldn't literally do the same procedure. I would probably like simply read the book and get it one time. I guess it all based on the course and then the work you have to do to understand it itself." SB(F)

"I think it was the whole change in environment…yes, at school we're in practicals and we're learning but when I'm at home by myself, I take the time out to understand on my own time. So while I'm at school and I'm learning content or I'm running from class-to-class, there's something new coming at me every minute and I have to learn it within a very specific time frame…when I'm at home and it's in the nights, I really get to sit back and break everything down for myself, without the distractions." SA(F)

Primary Themes – Learning Contents

"So, I didn't just use your material I used some material that they sent to us and some material from YouTube." MI(F)

"…normally after watching one of those I will watch another one to see how they correspond to see if they bring across the same information, because some are more detailed than some." SB(F)

"To properly identify WBCs, you have to draw from different sources, but the most helpful are the videos indeed and the different points that you also gave in the study guide that you prepared." SA(F)

Primary Themes – Relating and Structuring

"…put in a bit of life….real-life situations…. but just some real-life situations …I don't know how to bring that across, but just to compare it something familiar…something we can tie to understand it more …" MI(F)

“if there’s a problem and you’re not clear and you ask for clarification, it is given….you may not get it right away but the teacher will ask your peers if they understand and for them to explain…because sometimes students relates better to a next student than a teacher, in some instances. So after a classmate may do so, you might understand it and you’ll be like: ok… and then it might slip your mind when you come back out of class…..I just think you have to go home, watch the video and read your textbook and then you’ll be fine.” SB(F)

Primary Themes – Personally Interested

“I will probably give them a call, definitely. So, I will go to the extreme to reach out directly now to the lecturer because of what I am seeing on the paper...knowing that I wanted to get more information but didn’t get the chance to. So, what I do, Mrs. Munroe, I’ll definitely give them a call (once they said it was ok from the first that we can call) I’ll definitely do that, or I’ll send a WhatsApp message just for some more clarification…” MI(F)

“I actually find myself putting more effort in Haemat. I used to love MicroB….[…]…when it’s Haemat time I just get excited for class and such. So, it’s just like the more read it and the more you learn, you just want to put out more effort…” SB(F)

“When you understand that you did not know what they were or you were seeing things, but you didn’t know what they were…you have to go back and take your time to do it, outside of the timed session…on your own pace.” SA(F)

Secondary Themes – Construction of Knowledge

“So if say for instance I didn’t get to ask my question and I get the test and I did it...got it wrong (because I didn’t get any clarification) what I will try to do afterwards, I will try to do my own research. I will try to read up more on the specific topic…” MI(F)

“… I just think, a good idea is….[if the teacher tells the topic] watching the video and coming to class, prepared with the mind-set, is better…” SB(F)

Secondary Themes – Critical Processing.

“…so I prefer to watch the videos first because I like to get different opinions from other persons and then after gathering that information, I would take notes and I would go for the textbook to see how it correlates and if there is a little confusion there, then [the] Teacher…”

SB(F)

“ it’s also good that we have other teachers or other mediums to learn from…because sometimes learning from one person can get…I don’t know what word to use…but it’s like it’s not connecting anymore, but as soon as you hear someone else’s voice or as soon as you’re exposed to another teaching style, then it feels like things are flowing back and you’re understanding better.” SA(F)

For UDL Pattern

Secondary Themes – Ambivalent

"….What I do realize when you're learning, you don't know exactly at what point you're learning…because you think you understand something and then if you should ask a question…I take your survey for example [be]cause I did the survey immediately after I watched the video and I was understanding what you were saying…right, but then to answer the [tutorial] question, I didn't get it all correct. So even though I thought I understand, I didn't really or else I would have got everything correct with the cells that you asked us to identify. But then when I went over, listened to the review that you sent, went online and compared some other cells….to be honest, I don't know at which point exactly that learning does take place…[be]cause at first you think you understand…but then asking a question…I get it wrong…so maybe I didn't fully understand? So, I had to do more reading, research to fully understand it. So. to be honest, I'm not sure. I'm not sure.." MI(F)

"…….sometimes you don't have any motivation at all to understand anymore…". SA(F)

Secondary Themes – Lack of Regulation

"Alright. For example: a test (right?) - You're in the classroom, you understand what the Teacher is saying but then when you get the paper…I'm not sure if it's how it's asked? ..but I don't think that's the problem…but sometime I think it is though (thinking about it)…so it could be the way the question is asked…it wasn't taught the way it was asked on the paper...but that would simply mean that I didn't fully understand…thinking about it…but it happens almost all the time.
You're in the class, you think you understand but when you get the paper…you're like: What?? Yeah it happen all the time…all the time." MI(F)

"….because it feels like…….you're trying and trying and you're just not getting it…so I don't know if you understand what I am saying…" SA(F)

Secondary Themes – Stimulating Education

"…in the practical aspect, the videos did help me to learn better because for practical what I normally did was I normally read the textbook because that's all the practical teacher would say: go home and read this chapter and come back…" SB(F)

" I liked that you put the guides in a video format instead of like a booklet, because it keeps us engaged by having [you] talk back to us…….while if it were in a printed form, we are left to read it on our own and get distracted by other things that are more entertaining." SA(F)

Secondary Themes – Cooperative Learning

"…when I would ask someone else did you pass the test, what was it? And when we saw the grades coming down for the newer topic, persons got more grade for the older topic than the newer one. So, clearly everyone was having a problem with the newer topic…we had a

problem, so you couldn't really ask them because your classmates, themselves, wasn't even sure where they went wrong to get that such grades." SB(F)

"When you look at the grade and see how far you fell…knowing that you hold yourself at a standard that's much higher than that, it feels really bad….so you're going to try everything you can to change that…that includes…well, I haven't confronted the teachers as yet…because I have my own fear of that, but you try to learn from other students…you try to learn other materials from other sources…you try everything else, just to get back on track " SA(F)

For ADL Pattern

Secondary Themes – Use of Knowledge

"So if it can be taught in a way where it's better understand, where you just look at the smear (knowing the background information) looking at the smear and can distinguish it…that would be a good idea. Instead of you getting a smear and you know it's an abnormal blood cell but not sure of where to go from there." MI(F)

"To properly identify WBCs, you have to draw from different sources, but the most helpful are the videos indeed and the different points that you also gave in the study guide that you prepared….as well as actually going under the microscope and looking for them…" SA(F)

Secondary Themes – Vocation Oriented

"A particular module is offered at a specific time…[I] want to get it out of the way so I can move on to something else…" MI(F)

"I'm doing that course one time and one time only…likewise for Haemat 2…I'm not coming back in this class…when you get in that mindset that everyone keeps saying it's hard…and people keep failing and then you know that next year is supposed to be an internship and it's like…no...it's either you pass it or you pass the exam." SB(F)

Other Themes – Concrete Processing

"…I like real-life situations (I like that, to be honest). So when you can compare it to something we are familiar with…" MI(F)

Author's Declaration

Title: Using Digital Support to Assess & Promote Event-based Self-regulation in Cell Identification.

Supervisors:

Research Fellow, Katrin Saks
Senior Researcher Irene-Angelic Chounta

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