EVALUATING THE *DECODING THE DISCIPLINES* PARADIGM THAT IS USED FOR DEVELOPING DISCIPLINARY HABITS OF MIND: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

This article reports on a systematic review of the literature to evaluate the *Decoding the Disciplines* paradigm (henceforth "DtD") in the development of expert disciplinary habits of mind in student learning. A search was conducted utilising various databases (EBSCOhost, DOAJ, JSTOR, SAGE Journals Online, Scopus, Wiley Online and uKwazi) (Library Search Engine) for the period 2004 to 2020. More than 500 papers, retrieved from nine scholarly databases, were screened, based on title and abstract, resulting in 33 shortlisted papers for analysis. The researcher and one independent reviewer assessed the methodological quality of the shortlisted articles. Five countries are represented in this study. The results of this review highlighted the impact that the DtD has on the development of expert ways of thinking in learners. The case studies attest to the fact that several insights, namely 1) Concretising abstract phenomena; 2) Overcoming emotional bottlenecks; 3) Making expert habits of mind explicit to the learner; 4) Trans-disciplinary approaches and the T-Shaped learner and 5) Synergies between threshold concepts and information literacy habits of mind, are capabilities that the DtD process could cultivate in student learning to overcome complex bottlenecks.

Keywords: bottlenecks, Decoding the Disciplines, disposition, efficacy, habits of mind, mind theory, student learning, systematic review, troublesome knowledge, ways of thinking

INTRODUCTION AND BACKGROUND

It often occurs that investment of time and resources in teaching courses and modules yield poor results (Pace 2017). This is, to a great extent, due to the fact that learners experience hidden difficulties in many levels of their academic journeys. These bottlenecks or thresholds occasionally derail student learning and academic progress which may end in high student

failure rates. As teachers, we tend to assume that our students have already attained the necessary attributes or disciplinary ways of thinking that are needed for a successful academic career. Hence, we do not integrate our own expert habits and practices into learning outcomes when we prepare lesson plans, course content and learning assessments.

Typically, academic educators have course outlines and module descriptors with chronological lists of due dates for completing topics and learning assessments for their modules. Based on this customary practice, a pervasive discourse permeates the literature which epitomises the student as a "consumer of services" (Land 2016, 11). Hence, scholars recommend that course content should not be taught using prescriptive, linear methods as this might be counter-productive in the learning and teaching process. (Land 2016). The contention is that such pedagogic techniques do not foster habits of mind that are required for lifelong learning. First designed by Costa and Kallick (2000), it has been postulated that these disciplinary habits or ways of thinking are directly aligned with information literacy practices that graduates should acquire throughout their academic careers (Baer 2015).

Although significant research has been conducted in the area of Habits of Mind (Alhamlan et al. 2018), troublesome information literacy concepts (Gibson and Jacobson 2018) and Gofman (2019), it is evident that questions remain about the best ways to identify these challenges so that teachers may address the pertinent learning needs of struggling students. Unearthing challenges and including appropriate teaching methods to enable students to develop the desired expert proficiencies has been the main motivation behind the Decoding the Disciplines paradigm (henceforth the DtD).

The DtD model (Figure 1) provides guidelines for designing instructional, motivational and assessment strategies that support deep learning and for identifying and analysing disciplinary challenges in student learning. The model suggests that teachers, operating as experts in their disciplines, hold tacit knowledge and implicit ways of thinking that are not necessarily accessible to novices in the discipline. Its founder, David Pace, suggests that this seven-step cycle enables those implicit practices to be decoded so that learning bottlenecks or roadblocks could be alleviated. Pace (2017) believes that, through discussion with expert educators, disciplinary mental operations may be deconstructed to understand their tacit knowledge. Whereas Derrida's (1976) notion of deconstructing knowledge includes a more complex interpretation of language that accentuates thought processes in a poststructuralist manner, Pace (2017) associates the term or process of deconstruction with the conventional structuralist principle that spoken language can be accepted as the closest representation of thought (Higgs 2002). Derrida (1976), however, claims that all structures of meaning or interpretations are inherently unstable (Balkin 1995) and that all texts and utterances have

multiple meanings that conflict with each other. This seems to be in stark contrast with Pace's general, simplistic description of the process of deconstructing ways of thinking, being and becoming, which, he maintains, may easily be deciphered through an interview with an expert educator. Despite the philosophical underpinnings of the term as advocated by Derrida (1976), this study uses Pace's (2017) interpretation of "deconstructing" to simplify and contain the meaning of complex phenomena and thoughts.

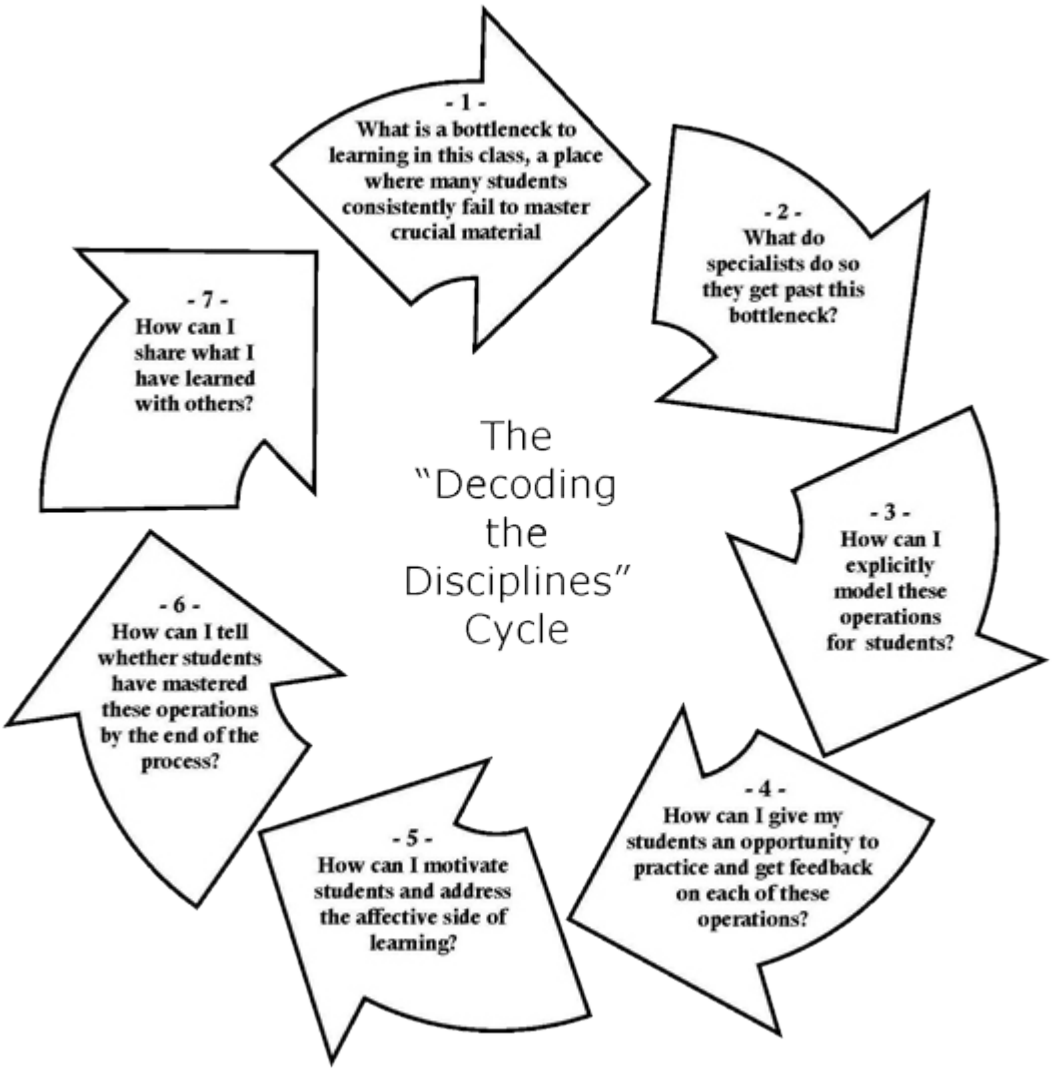


Figure 1: Decoding the Disciplines Paradigm (Hlp.sitehost.iu.edu)

Furthermore, Roland Barthes (Bathes, Miller, and Howard 1974), who is a key participant in the philosophy of deconstruction, argues that our role is active rather than passive in our interpretation of texts. He, like Derrida (1976), challenges the "restrictive reading experience under structuralism and says that meaning making is not limited to the author only who claims to know the truth" (Jadoon, Naqi, and Imtiaz 2020, 244). All readers actively interpret the text

instead of looking at fixed, single or final meanings. This gives the reader more agency to derive meaning from studies and to respond to its ideas. Taking into consideration Barthes et al.'s (1974) perspective, we, as readers of the review articles, used Pace's (2017) DtD model as a guide to interpret the articles.

Thus far, there have been only positive responses to the DtD model which further reinforces the purpose for this review which is to investigate the efficacy of the DtD process on the development of expert disciplinary Habits of Mind or ways of thinking in student learning.

The findings of the review may be used to create a shift in the mindset of the disciplinary academic teacher with regards to recognising the nature and extent of their own submerged habits of mind. While many academics may be aware of disciplinary blind spots, few realise that learners need to be taught new mental models which focus on understanding the core ideas about information and scholarship within their disciplines.

A systematic review of the literature in this regard will enable the researcher[1] to explore whether the DtD Paradigm contributes to the development of expert habits of mind. Since its inception in 2004, a body of literature has proliferated, but this is the first systematic review conducted on the research pertaining to the DtD model.

METHODOLOGY

This study utilised a systematic review methodological approach. The process is defined as a "systematic and explicit method to identify, select and critically appraise relevant research" (Isaacs and Andipatin 2020, 2). Data is then subsequently extracted and analysed from shortlisted studies. This protocol is claimed to be a "standardized method" (Boell and Cecez-Kecmanovic 2015, 162) which renders it replicable and transparent for researchers who may desire to conduct the same or similar review.

The aim of the review is to evaluate and summarise various local and international studies on the efficacy of the DtD model for the development of expert habits of mind in student learning. This methodology was considered to be the most appropriate method to interpret findings in a rigorous, methodical and coherent manner as it may also be considered transparent and free from bias.

Therefore, the review was guided by a valued and competent colleague who assisted with verifying the validity and credibility of the process. Although the reviewer had not previously been involved in the process of conducting a systematic review, he was briefed on the methodology and all the steps required for this procedure. The reviewer[2] spent considerable time consulting the necessary literature to familiarise himself with the various steps of a systematic review.

The review question

An appropriate and relevant research/review question was developed using the acronym SPICE (Setting, Perspective, phenomenon of Interest/Intervention, Comparison, Evaluation). The main research question was: How effective is the Decoding the Disciplines model in developing expert disciplinary habits of mind in university students?

Objectives of the review

In order to assess the efficacy of the model in question, the following specific objectives of the review have been identified, which would be to ascertain:
1) the nature of the bottleneck(s) identified; 2) the habit(s) of mind envisaged to be developed through the DtD intervention; 3) the nature of university settings in which DtD has been used; 4) the disciplines in which DtD has been applied; 5) the types of courses in which the DtD has been applied; 6) the methods of application (steps followed) of the DtD intervention; 7) the results and outcomes supporting or rejecting the DtD intervention.

The review process

This systematic review comprises four steps. The first step (identification) involved identifying and retaining relevant studies that may be included in the review. To complete this process, keywords were identified and searches were conducted across a number of the University of the Western Cape (UWC) databases. The second step, called screening, consisted of assessing the abstracts of all the included articles to ensure that they complied with the inclusion criteria. The third step, eligibility, is executed when the selected articles are screened for methodological rigour using a critical appraisal tool. The fourth step, called data extraction, involves selecting relevant data from each article that relate to the study objectives. The entire process for this review is discussed in detail below and illustrated in Figure 2.

Literature (electronic) search strategy

To retrieve records on the application of the Decoding the Disciplines paradigm, an electronic search was conducted across 9 databases between September 2020 and November 2020. Databases listed in Table 1 relate to the Education discipline. Each database displays unique search techniques and coverage of the topic as well as controlled vocabulary.

Information sources

A search was conducted across UWC databases such as Ebscohost (Academic Search Complete, ERIC and SocIndex); JSTOR, DOAJ, Scopus, Sage Journal Online, Wiley Online and the University of the Western Cape Library search engine, uKwazi. To retrieve specific,

relevant results pertaining to the effectiveness of the Decoding the Disciplines model on developing disciplinary habits of mind, a number of search strings were used: "Decoding the Disciplines"; "Decoding the Disciplines" AND "Critical thinking"; "Habits of Mind" AND "Decoding the Disciplines"; "Decoding the Disciplines" AND Disposition*; Habits of mind OR "Mind theory" AND "Decoding the Disciplines"; "student learning" AND "Decoding the disciplines"; "Decoding the Disciplines" AND "Ways of thinking"; "Student performance" AND "Habits of Mind" AND "Decoding the Disciplines". These keywords and related synonyms were used as it responds to the research question and seeks to explore its relevant issues.

Table 1 represents the inclusion and exclusion criteria of the literature search, the databases used for the search, including the final version of the search strategies. The researcher and the reviewer decided to exclude the databases *Google Scholar* and *Library and Information Science Source* as all records should fall within the ambit of the relevant discipline which is Teaching and Learning (Education).

Two conference papers and 1 PhD dissertation were located using alternative methods due to the fact that these 3 documents are inaccessible. Their authors generously provided the full texts via email.

Eligibility criteria (inclusion criteria)

Studies were included if they met the following criteria: a) Full-text qualitative; b) Journal articles, book chapters, conference papers and book reviews. The latter was considered as it may lead to relevant monographs on the Decoding the Disciplines model; c) The papers should be published between 2004 and 2020. When the Decoding the Disciplines model was first developed in the early 2000's, the first publications on empirical studies in this regard ensued in 2004.

Study selection

The researcher used eight search strings to search across the databases using All Fields, Title and Abstract limiters. However, she noted that the All Fields option generated too many searches.

Circumventing the risk of bias

Conducting searches across databases

The researcher's interpretation and individuality in selecting and judging the studies and findings are to be minimised during the systematic review process (Boell and Cecez-

Kecmanovic 2015). Therefore, a reviewer is required to help researchers become more critical and reflective in evaluating the studies. The assigned reviewer verified the results obtained from all title and abstract searches. The reviewer used each search string, limiters and inclusion criteria to search for relevant documents in each database.

Due to the COVID-19 pandemic, it was not possible for the researcher and the reviewer to meet in a face to face environment. Therefore, they had collaborated in virtual Zoom meetings where the searches were conducted and verified by the researcher. The reviewer highlighted all discrepancies and appended it in an excel sheet that was uploaded to the Google Drive. He occasionally emailed captured screenshots of his searches to the researcher to emphasise and clarify any inconsistencies that he detected. This is in keeping with the scholarly guidelines provided for conducting a systematic review.

Table 1: Inclusion and exclusion criteria, selected databases and final search strings

Inclusion Criteria	Full Text documents Journal Articles; Book Chapters; Conference papers; book reviews Publication Year 2004–2020 English Language
Exclusion Criteria	Foreign Language documents Commentaries Editorials
Databases	• **EBSCOhost** Includes: *Academic Search Complete*, *ERIC* (Education Resource Information Center), *SocINDEX with Full Text* (The world's most comprehensive and highest quality sociology research database. SocINDEX with Full Text offers coverage from all subdisciplines of sociology) • **DOAJ** (Directory for Open Access Journals (DOAJ is a community-curated list of open access journals and aims to be the starting point for all information searches for quality, peer reviewed open access material) • **JSTOR** (An online journal archive providing access to back issues of core scholarly journals in arts, humanities, business, social sciences, ecology, botany, language and literature) • **SAGE Journals Online** (prestigious and highly cited journals are available electronically on the award-winning SAGE Journals Online platform. Search across 560 journals in Business, Humanities, Social Sciences, and Science, Technology and Medicine) • **SCOPUS** (a multidisciplinary navigational tool that contains records going back to the mid-1960s, offering newly-linked citations across the widest body of scientific abstracts available in one place. More coverage of scientific, technical, medical and social science literature (14,000 titles) than any other database) • **Wiley Online** (a leading international provider of scientific, technical, medical, and scholarly journals. In 2008, Wiley InterScience incorporated the online content formerly hosted on Blackwell Synergy to provide access to over 3 million articles) • **Library Search engine (*uKwazi*)**. (*uKwazi* (isiNguni word which means "to know") enables you to search across the library's entire collections, both print and online resources)
Search Strings	"Decoding the Disciplines" "Decoding the Disciplines" AND "Critical thinking" "Habits of Mind" AND "Decoding the Disciplines" "Decoding the Disciplines" AND "Disposition" "Habits of mind" OR "Mind theory" AND "Decoding the Disciplines" "Student learning" AND "Decoding the disciplines" "Decoding the Disciplines" AND "Ways of thinking" "Student performance" AND "Habits of Mind" AND "Decoding the Disciplines"

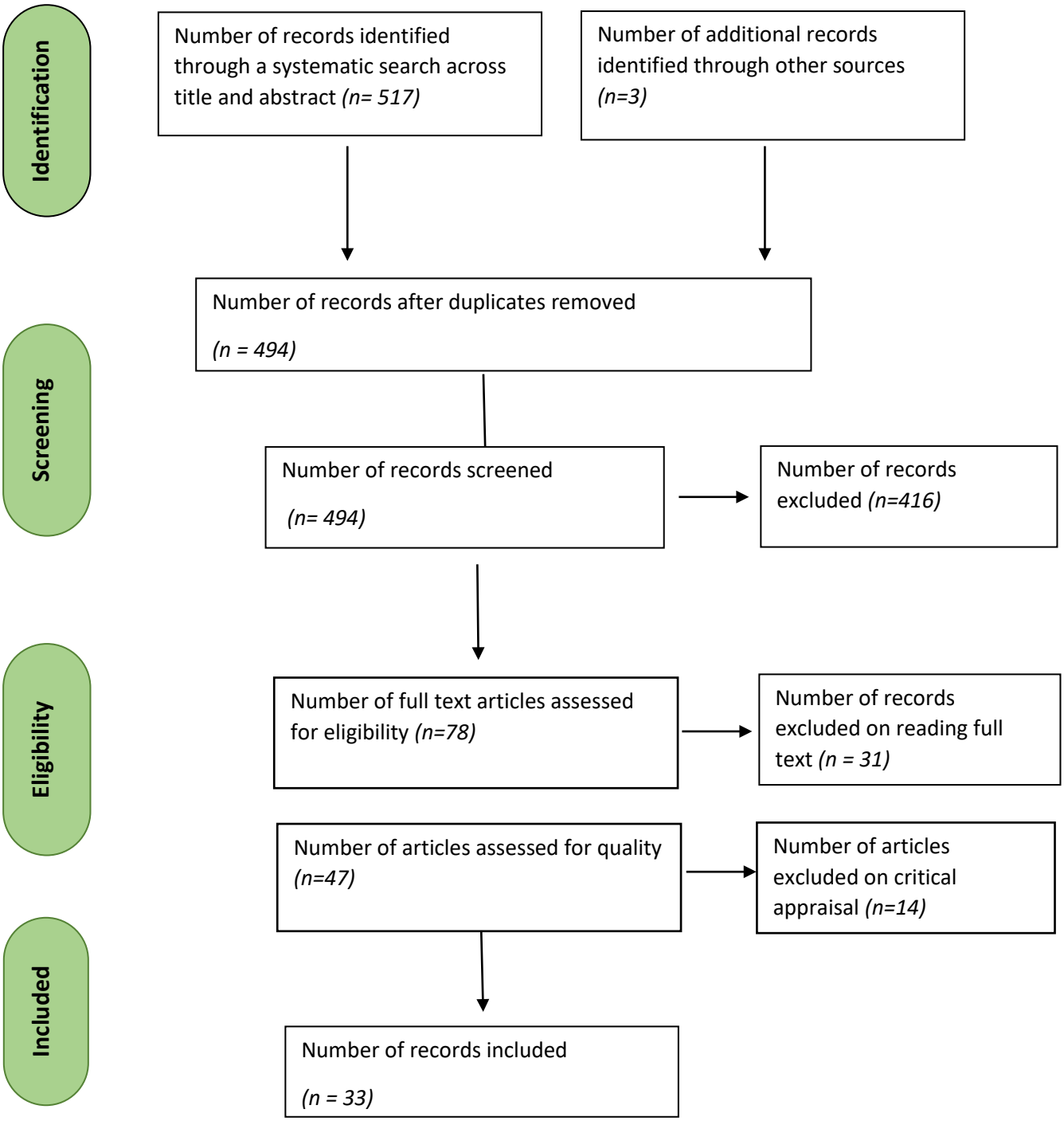


Figure 2: Flow chart of study screening process

METHODOLOGICAL QUALITY APPRAISAL OF THE ARTICLES

In order to evaluate the 47 articles, we decided to use the Critical Appraisal Skills Programme (CASP) tool, which is claimed to be the "most commonly used tool for quality appraisal in health-related qualitative evidence syntheses, with endorsement from the Cochrane Qualitative and Implementation Methods Group" (Long, French, and Brooks 2020, 31). The researcher and reviewer chose this tool for this study's critical appraisal since it comes "highly recommended

for novice qualitative researchers" (Long et al. 2020, 31).

As illustrated in Figure 2, forty-seven (n=47) studies formed part of the methodological appraisal section of the review. The criteria used for assessing the methodological rigour and quality of the selected studies included research design, data collection methods, steps in the decoding process, data analysis, ethical considerations as well as the potential value of the studies for future pedagogical practices. The researcher and reviewer applied a threshold of 65 per cent to appraise the studies. Of the 47 studies appraised, 22 studies were classified as "strong" (80–100%), while the 12 studies in the "moderate" (65–79%) category were also included in the review. Although these studies lack explicit discussions of research methods and ethical procedures, they examined how various steps of the Decoding model are used in student learning. Therefore, the reviewer and author decided not to exclude these case studies from the final review. Fourteen (n=14) studies were evaluated as "weak" (>65%) and were consequently excluded from the review. These studies failed to discuss specific learning bottlenecks as well as how the DtD model was used to develop disciplinary habits of mind. The remaining 33 studies were included in the final review process.

Table 2: Ranking according to critical appraisal tool

Zolan, Strome and Innes (2004)	70%
Schlegel and Pace (2004)	70%
Durisen and Pilachowski (2004)	70%
Burkholder (2011)	70%
Zhu, Rehrey, Treadwell and Johnson (2012)	70%
Ardizzone, Breithaupt and Gutjahr (2004)	70%
Kurz and Banta (2004)	70%
Pace, David.2004	70%
Sundt, Jody (2010)	70%
Pace, David. (2011)	70%
Grim, Pace, and Shopkow (2004)	70%
Rubin and Krishnan (2004)	80%
Yeo (2017)	80%
Riegler. (2019)	80%
Pinnow (2016)	80%
Lee-Post (2018)	80%
Yeo (2017). Hermeneutic	90%
Cameron (2019)	90%
Khomokhoana and Nel (2020)	90%
Verpoorten et al. (2017)	90%
Attas (2018)	90%
Miller-Young (2015)	90%
Diaz (2008)	90%
Fischer (2018)	90%

Sturts and Mowatt (2012)	90%
Currie (2017)	90%
Miller (2018)	90%
Miller-Young and Boman (2017)	90%
Middendorf, Mickutė, Saunders, Najar, Clark-Huckstep and Pace. (2015)	90%
Pettit (2017)	90%
Mohamed (2020)	100%
Tingerthal (2013)	100%
Rousse, Mary, Julie Phillips, Rachel Mehaffey, Susanna McGowan, and Peter Felten. (2017)	100%

The researcher and reviewer discussed each article to confirm its inclusion in the review. The two parties deliberated about questions pertaining to ethics and research methods as these matters were not always made explicit in every case study. An informed decision was made that, where articles did not address ethical procedures and in instances where research methods were not discussed, the study in question should *not* be excluded on the basis of those criteria. This decision was especially reinforced where such articles comply with all other factors, for instance where the study explains how the DtD model influenced student performance. This would constitute a worthy item for review.

It is worth noting that any disagreements between the researcher and the reviewer were resolved during telephonic discussions to reach consensus. The discrepancies and disagreements in this regard, were considered as miniscule.

RESULTS

Data extraction and overview of reviewed studies

The final step of the review process is the synopsis whereby data was extracted from the 33 shortlisted studies. The researcher read through all the articles and identified significant and relevant themes that addressed the research question.

Table 3 categorises the data into criteria that were used to compile the results for the review. The 33 selected articles discussed the nature of the bottlenecks, habits of mind that needed to be developed to overcome complex learning problems and at least one outcome of the study. These headings were chosen because they are aligned with this review's objectives and main research question.

Table 3 provides a portion of the analysis to expound the process of the data extraction as discussed below.

Table 3: Description of data extraction

Author	Study design and Population Size	Setting	Nature of bottleneck	Habits of mind that need to be developed	Method of application of the DtD model (steps used and applied)	Results and outcomes of intervention
Pinnow, E. (2016). Decoding the Disciplines: An approach to scientific thinking	Case-control study Control Group: n=45, DtD group: n=46. Introductory psychology courses	University of Wisconsin, USA	Students, however, often struggle to reconcile their ideas about psychology with the fundamental role of the scientific method in psychology. A common complaint among nearly all psychology instructors is their students' inability to differentiate between independent and dependent variables.	Conceptualising; Visualising abstract phenomena	Steps 1 – 6	Three independent samples t-tests compared performance on each of the assessment measures (hypothesis generation, identifying variables, and creating operational definitions). Students who were taught using the Decoding the Disciplines technique were more likely to generate complete hypotheses that looked at relationships between two variables. Similarly, students in the Decoding the Disciplines condition outperformed students in the Control condition in writing operational definitions. It is clear that the Decoding the Disciplines methodology offers an effective form of active learning. The Decoding the Disciplines method also offers potential for other bottlenecks for students within the field of psychology such as the basis of neural communication, the logic of p values, or the Opponent-Process Theory.

Study design

This review focused on publications which used a qualitative research method. The DtD model was applied to gain insight into student difficulties and to explore the depth and complexity inherent in this phenomenon.

The final sample of 33 studies which were included in the systematic review provides detailed descriptions of how the model was applied in teaching and learning.

The studies comprised of *23 single case studies*: (Zolan et al. 2004, 23 – 32; Mohamed, S. 2020, 182–209; Rubin and Krishnan 2004, 67–73; Yeo et al. 2017, 49–62; Cameron 2019, 675–84; Khomokhoana and Nel 2020, 17–32; Middendorf, Mickutė, Saunders, Najar, Clark-Huckstep and Pace 2015, 166–180; Pace 2011, 107–119; Miller-Young and Boman 2017, 19–35; Sturt and Mowatt 2012, 39–45; Fischer 2018, 149–159; Diaz 2008, 1211–1224; Pace 2004, 13–21; Kurz 2004, 85–94; Attas 2018, 1–23; Ardizzone 2004, 45–56; Chen Zhu et al. 2012, 54–60; Verpoorten et al. 2017, 263–267; Rousse et al. 2017, 1–14; Pinnow 2016, 94–101; Durisen 2004, 33–43; Schlegel 2004, 75–83; Yeo 2017, 87–96); *1 self-study*: (Pettit 2017, 75–85); *6 auto-ethnographic studies* (Tingerthal 2013 (Dissertation); Grim et al. 2004, 57 – 65;

Sundt 2010, 267–284; Miller-Young 2015, 32–57; Burkholder 2011, 93–111; Riegler 2019, 685–691); *1 pilot study*: (Miller 2018, 412–418); *1 phenomenological study*: (Currie 2017, 37–48) and *1 research paper*: (Lee-Post 2019, 398–414).

Demographics

The articles which were screened portrayed the following geographical locations: *3 studies in Canada*: (Miller-Young and Boman 2017, 19–35; Yeo 2017, 87–96; Attas 2018, 1–23); *2 studies in Germany*: (Riegler 2019, 685–691; Fischer 2018, 149–159); *1 study in Belgium*: (Verpoorten et al. 2017, 263–267); *2 studies in South Africa*: (Mohamed, S. 2020, 182–209; Khomokhoana and Nel 2020, 17–32) and *25 studies in the USA*: (Zolan et al. 2004, 23–32; Rubin and Krishnan (2004), 67–73; Yeo et al. 2017, 49–62; Cameron 2019, 675–684; Middendorf et al. 2015, 166–180; Pace 2011, 107–119; Sturts and Mowatt 2012, 39–45; Diaz 2008, 1211–1224; Pace 2004, 13–21; Kurz 2004, 85–94; Ardizzone 2004, 45–56; Zhu et al. 2012, 54–60; Rousse et al. 2017, 1–14; Pinnow 2016, 94–101; Durisen 2004, 33–43; Schlegel 2004, 75–83; Pettit 2017, 75–85; Tingerthal 2013; Grim et al. 2004, 57–65; Sundt 2010, 267–284; Miller-Young 2015, 32–57; Burkholder 2011, 93–111; Miller 2018, 412–418; Currie 2017, 37–48; Lee-Post 2019, 398–414). The body of literature under review ranges between the periods 2004 and 2020.

Sample populations were selected from undergraduate students at various tertiary institutions. Samples sizes ranged between 45 heterogenous students and 250 students in a particular control group. A huge proportion of the selected articles contained unspecified numbers of students.

Case studies were undertaken across a range of disciplines such as Introductory Psychology courses, Biology, Marketing and Statistics, History, Psychology, Computer Science, Business Finance, Astronomy, Mathematics, Cognitive Psychology, Nursing, Engineering, Journalism, Library and Information Science, Recreation, Park and Tourism Studies, Political Science, Service Learning and Community Engagement, Music Analytics, Geology, Creative Writing, Marketing and Business and Finance.

The nature of the bottleneck

Having been applied and tested across a number of disciplines, the DtD model was used to identify several student learning challenges that are commonly referred to as “bottlenecks”. The selected case studies depict these various difficulties which are described and reported on by experts in their respective fields. According to Pace (2017), bottlenecks may be categorised as *epistemological, procedural and emotional*.

a) Epistemological bottlenecks

Of the 33 selected studies, 25 studies (Tingerthal 2013; Riegler 2019, 685–691; Cameron 2019, 675–684; Khomokhoana and Nel 2020, 17–32; Zolan et al. 2004, 23 – 32; Yeo et al. 2017, 49–62; Rubin and Krishnan 2004, 67–73; Burkholder 2011, 93–111; Mohamed 2020, 182–209; Lee-Post 2019, 398–414; Zhu et al. 2012, 54–60; Ardizzone 2004, 45–56; Attas 2018, 1–23; Pettit 2017, 75–85; Miller-Young 2015, 32–57; Fischer 2018, 149–159; Sundt 2010, 267–284; Currie 2017, 37–48, Sturts and Mowatt 2012, 39–45; Yeo 2017, 87–96; Pace 2004, 13–21; Pace 2011, 107–119; Diaz 2008, 1211–1224; Grim et al. 2004, 57–65; Schlegel 2004, 75–83) discuss epistemological bottlenecks which are characterised by an inability to understand how knowledge is constructed within a discipline. An example of this type of challenge is prevalent in courses where learners struggle to comprehend what "counts" as evidence to support an argument (Brigham University, https://ctl.byu.edu/tip/identify-bottlenecks-student-learning-develop-improved-learning-strategies). These challenges include specific instances where learners may not understand how to generate knowledge within a specific field. This particular epistemological bottleneck is prevalent in 16 case studies (Grim et al. 2004; Grim, Pace, and Shopkow 2004, 57 – 65; Diaz 2008, 1211–1224; Pace 2004, 13–21; Pace 2011, 107–119; Yeo 2017, 87–96; Sundt 2010, 267–284; Fischer 2018, 149–159; Miller-Young 2015, 32–57; Pettit 2017, 75–85; Kurz 2004, 85–94; Attas 2018, 1–23; Ardizzone 2004, 45–56; Zolan et al. 2004, 23–32; Riegler 2019, 685–691; Durisen 2004, 33–43; Tingerthal 2013). The remaining articles expand on epistemological bottlenecks detailing students' difficulty to align abstract ideas or models to specific evidence in the discipline (Mohamed 2020; Cameron 2019); their inability to connect facts to a coherent whole instead of committing it to memory (Khomokhoana and Nel 2020; Schlegel 2004; Zolan et al. 2004); and the challenge experienced when learners are asked to measure time and space (Zhu et al. 2012).

b) Procedural bottlenecks

Five articles of the 33 studies addressed learning challenges which may be classified as procedural bottlenecks. This troublesome knowledge begins where learners have difficulty completing tasks, or where successful completion thereof requires multiple steps. An example is found in Pinnow (2016) where the steps involved in formulating a hypothesis, identifying competing hypotheses, and writing a literature review (Rousse 2017) were evaluated using the Decoding model.

c) Emotional bottlenecks

Aside from Pinnow (2016), one other study focused on emotional bottlenecks, which occur

when students respond with emotion to difficulties or to subject matter that derails their learning. (Brigham University, https://ctl.byu.edu/tip/identify-bottlenecks-student-learning-develop-improved-learning-strategies). Middendorf and Pace (2004) address this issue and discuss the repercussions when students feel that their ancestral rights are questioned in History or when they believe that their religious beliefs are threatened if they study or accept the concept of evolution in Biology.

Identifying expert habits of mind

The ways of thinking, being and doing that were identified in the final selection of the 33 chosen case studies, were categorised into 5 disciplinary habits of mind that students should internalise when engaging with their respective disciplines: 1) Perceiving scholarship as dialogic and as a symbolic conversation; 2) Solving problems through a process of iterative enquiry; 3) Recognising the authority of evidence as a contextual and constructed phenomenon; 4) Selecting and using information sources for particular purposes and audiences; and 5) Practicing mental flexibility and perseverance when searching for information. This review found that some of these themes permeate the above-mentioned case studies.

Perceiving scholarship as dialogic

Thirteen shortlisted studies (Pace 2004; Schlegel 2004; Ardizonne 2004; Attas 2018; Diaz 2008; Fischer 2018; Sturts and Mowatt 2012; Sundt 2010; Currie 2017; Miller 2018; Miller-Young 2015; Middendorf et al. 2015; Pettit 2017) discussed the development of this disciplinary habit of mind which requires the understanding that scholarly research in various disciplinary fields is a discursive practice where ideas are generated, debated and weighed against each other.

Three studies identified expert practices that consider the contribution which information sources make to History, Physiology and Phenomenology (Schlegel 2004; Pace 2004; Currie 2017). One study (Sundt 2010) discussed the importance of seeking out conflicting perspectives in the area of Criminal Justice as well as being aware that one enters a scholarly conversation which is incomplete and constant. Experts maintain that, in addition to perceiving scholarly conversations as dialogic, learners should summarise the changes in perspective over time on a particular topic within a discipline. Two studies (Ardizzone 2004; Pace 2004) found that it is important to interpret poetry and fiction within its historical contexts and to become familiar with various literary conventions that were applied over periods of time. This way of thinking can also be applied when analysing historical artefacts.

The remaining 8 studies (Attas 2018; Diaz 2008; Fischer 2018; Sturts and Mowatt 2012;

Miller 2018; Miller-Young 2015; Middendorf and Pace 2004; Pettit 2017) identified tacit mental operations that are often mistakenly assumed in student learning: The disciplinary practitioner knows that prescribed scholarly material do not represent the only opinion on a matter (Attas 2018; Schlegel 2004; Pace 2004; Pettit 2017) and that learners should seek other conflicting perspectives. By voicing their own interpretations (Diaz 2008), learners would soon realise that they are not passive consumers of knowledge but that they are able to become active contributors to scholarship.

Similarly, the disciplinary unconscious mind of the expert recognises instances where it becomes necessary to suspend judgement on the value of a particular argument until the larger context of the scholarly conversation is holistically understood (Fischer 2018; Miller 2018; Sturts and Mowatt 2012).

Solving problems through a process of iterative enquiry

Of the 33 studies, 17 articles (Zolan et al. 2004; Mohamed 2020; Rubin 2004; Yeo 2017; Cameron 2019; Schlegel 2004; Khomokhoana 2020; Durisen 2004; Pinnow 2016; Lee-Post 2019; Verpoorten et al. 2017; Zhu et al. 2012; Pace 2004; Miller-Young 2015; Sundt 2010; Miller 2018; Miller-Young and Boman 2017) examined the habit of mind that requires learners to question and to "move beyond memorisation" in Genetics and Molecular Biology (Zolan et al. 2004), to organise information in meaningful ways in Business and Finance, Criminal Justice and Library and Information Science (Sundt 2010; Mohamed 2020; Miller 2018) including the ability to recognise main complex ideas and filter these into manageable chunks (Sundt 2010; Miller 2018). Moreover, the iterativeness of problem-solving was discussed, suggesting that a hermeneutic approach (Yeo 2017) could lead to the development of a questioning attitude towards research. Notwithstanding that problem-solving is a collaborative activity, this does not exclude learners from engaging in independent thinking.

Some studies (Miller 2018) complement the notion of iterative inquiry as emphasised in the ACRL Framework (2016) where this process "extends beyond the academic world to the community at large, and which may focus upon personal, professional, or societal needs" (ACRL 2016, 7). This way of thinking is an area for development in courses such as Marketing, Geology and Service Learning (Rubin 2004; Zhu et al. 2012; Miller-Young 2015). Remaining aspects of problem-solving is evident in studies where learners are expected to turn concrete, abstract questions into measurable ones as depicted in Introductory Psychology, Geology, Computer Source Coding, Service Learning and Criminal Justice (Pinnow 2016; Zhu et al. 2012; Khomokhoana 2020; Miller-Young 2015; Sundt 2010).

Recognising the authority of evidence as a contextual and constructed phenomenon

Five shortlisted studies (Grim, Pace, and Shopkow 2004; Pace 2004; Schlegel 2004; Sundt 2010; Miller 2018) focussed on the expert capacity to assign trust to evidence within particular contexts and to understand that evidence is constructed in various ways by communities of practice.

One study (Pace 2004) emphasised that to think like a historian, students must select and assess evidence that supports interpretations of the meaning of the past. It found that students need to develop an understanding of the social nature of the information ecosystem where authorities actively connect with one another and that these sources develop over time. Eleven shortlisted studies (Sundt 2010; Miller 2018) posit that students should be able to evaluate the logical relationship between evidence and a study's findings such as those in Research Methods and Library and Information Science. Similarly, 1 study (Schlegel 2004) found that it is imperative to develop an awareness of the importance of assessing evidence with a sceptical stance. Using evidence to shape the historical imagination is also an expert disciplinary habit of mind as maintained in Grim et al.'s (2004) study on learning how to use evidence in History.

Selecting and using information sources for particular purposes and audiences

Six shortlisted studies identified the tacit assumption that learners are aware of the reasons why and how information is created. This theme advocates an understanding that experts look beyond format when choosing resources to use in their research. This review found that disciplines such as Business and Finance, Engineering, Language Comprehension, Cognitive Psychology, Library and Information Science as well as Music History and Analysis require learners to recognise the nature of information creation and the underlying processes thereof. The expert understands that each final product is packaged with different capabilities and constraints.

Learners often reach a bottleneck where they are unable to distinguish between various formats of information (Mohamed 2020; Attas 2018; Riegler 2019; Cameron 2019; Miller 2018 and Tingerthal 2013). For instance, the failure to recognise that information may be perceived differently based on the format in which it is packaged is discussed in detail in Tingerthal (2013) and Mohamed (2020).

Practicing mental flexibility and perseverance when searching for information.

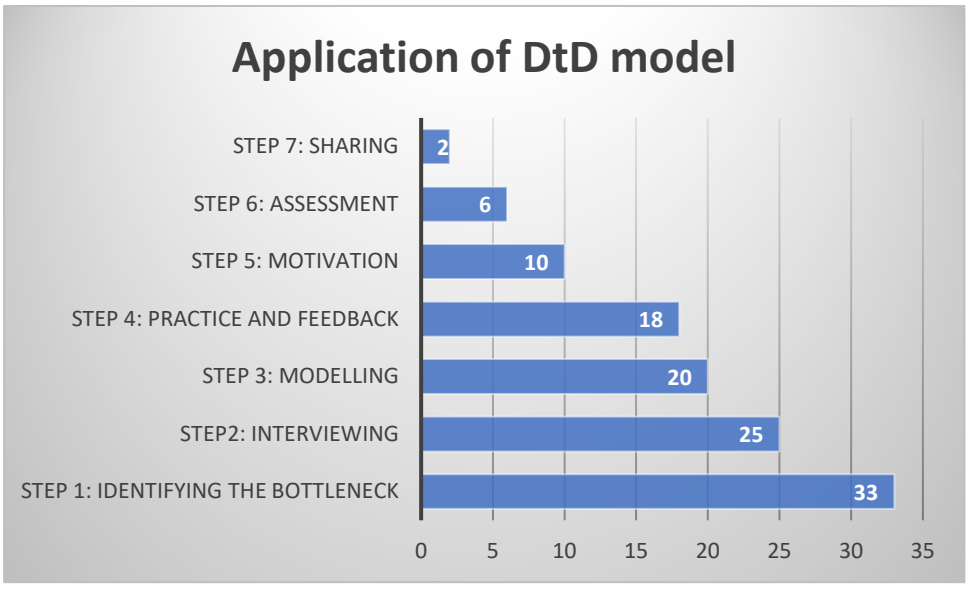
The researcher and the reviewer found that authors in the following 3 shortlisted studies (Sundt 2010; Schlegel 2004; Pace 2004) identified expert ways of thinking that are aligned with

information seeking behaviour. It is imperative to teach the notion that the searching for information is not a linear step by step process but should be regarded as an exploration which requires mental flexibility and perseverance. This process is often affected by cognitive, affective and social dimensions (ACRL 2016).

These 3 studies (Schlegel 2004; Sundt 2010; Pace 2004) found that expert practitioners do not have to search through all information resources to access relevant material in for instance, Criminal Justice (Sundt 2010) – they are able to identify paradigms and schools of thought that could answer their research questions. Similarly, these studies identified habits that students should acquire such as realising that information vary in content and format. Historical artefacts, for example, have different degrees of significance, depending on the needs of the search.

Findings: The application of the Decoding the Disciplines model in developing expert habits of mind

To alleviate and overcome the bottlenecks which were identified in these selected studies, various steps in the decoding model were implemented. The total number of studies (n=33) which forms the body of literature for this review, used the first step in the decoding process to identify the bottleneck in student learning. However, each study selectively applied certain steps of the Decoding model. Those which were preferred and deemed necessary to assist with alleviation of a bottleneck constituted the main focus of a particular study. Thus, it was found that analysis of the seven steps of this model were dispersed across all the case studies.



Twenty-five studies of the shortlisted cases (Mohamed 2020; Tingerthal 2013; Miller-Young

2015; Currie 2017; Fischer 2018; Sundt 2010; Miller 2018; Diaz 2008; Sturts and Mowatt 2012; Yeo 2017; Riegler 2019; Yeo 2017; Cameron 2019; Pinnow 2016; Burkholder 2011; Middendorf 2015; Rousse 2017; Lee-Post 2019; Verpoorten et al. 2017; Pace 2004; Zhu et al. 2012; Attas 2018; Pace 2011; Pettit 2017; Miller-Young and Boman 2017) applied the interview technique (Step 2) to unlock the disciplinary unconscious of the expert practitioner. This is an attempt to unearth ingrained knowledge that has become submerged beneath the lecturer's teaching practices and needs to be made explicit in the classroom.

The review found that 20 selected studies applied Step 3 (Modelling) as a means of reframing teaching practices to alleviate the bottlenecks which were identified in their modules. In most instances, the lecturer employed various tasks (Step 4) such as collaborative learning in class, questionnaires, observations, minute papers; video clips, index cards, discussions; group work, pre – and – post assessment as well as the use of MCQ questionnaires to measure understanding. A noticeable number of studies (10) analysed emotional blockages (Step 5) in learning, while only 6 studies concentrated on summative assessments (Step 6) to monitor progress and to test whether learners have managed to overcome the threshold. The final step in the Decoding model (Step 7) involves sharing the outcomes of the studies with a larger community of practice. Only 2 studies included this task (Tingerthal 2013; Pace 2011).

DISCUSSION

Significant insights achieved through decoding liminal areas in student learning

Irrespective of whether these 33 studies were research-driven (observational, empirical) or self-directed, it may be deduced that the majority of the reviewed studies illustrated a positive predisposition towards the Decoding the Disciplines model. With the exception of one or two instances, the general outcome is that the Decoding model aids student learning in substantial ways. To assist with the investigation into the efficacy of the model on the development of expert habits of mind, the researcher categorised the following observations and insights into 5 parts: 1) Concretising abstract phenomena; 2) Overcoming emotional bottlenecks; 3) Making expert habits of mind more explicit for the novice learner; 4) Trans-disciplinary approaches and the T-Shaped learner; 5) Synergies between threshold concepts and information literacy habits of mind.

Concretising abstract phenomena

Five shortlisted studies (Zolan et al. 2004; Zhu et al. 2012; Ardizzone 2004; Cameron 2019;

Durisen 2004) found that modelling intricate processes in disciplines such as molecular biology, geological time frames, eye movement during graph reading exercises and astronomical concepts, serve to teach students to *visualise* abstract ideas. Researchers realised that the modelling process, which is the third step in the Decoding model, may include the expert practitioner's mental operations. These are transformed and concretised as analogies or metaphors in the classroom. The decoding process helped instructors to understand the reasons why many learners fail to comprehend the meaning of abstract phenomena from schematic diagrams or illustrations, "even when supported by explanatory texts" (Durisen 2004, 43). Common bottlenecks in this regard include the inability to visualise the size and scale of astronomical concepts (Durisen 2004), geological scale and time (Zhu et al. 2012), biological processes such as meiosis and mitosis (Zolan et al. 2004), and graph reading (Cameron 2019). In each case, the value and formidability of abstract content is expounded through making this step an integral part at programme and course level.

Overcoming emotional bottlenecks

The identification of emotional or affective blockages in student learning is addressed in 6 selected studies (Currie 2017; Sundt 2010; Fischer 2018; Pace 2004; Diaz 2008; Middendorf 2015). In one particular study, faculty came to realise that their own authentic experiences in clinical settings or journalism enabled them to fully embody and understand disciplinary concepts. The interviews that were conducted in this study elicited the conscious connections between instructors and their own interpretations of difficult concepts. According to Currie (2017) "touch, perceptions, feelings, actions and sensations" cannot be translated in course content or lesson plans. These affective experiences should be given explicit attention and integrated into pedagogical practices. The Decoding model makes provision for this procedure in the fifth step of the learning cycle.

The remaining four studies reiterate the value of overcoming cognitive dissonance through making hidden emotional operations transparent. Fischer (2018) and Sundt (2010) attest to the fact that it is important to gain insight into some of the emotional causes of such dissonance which could threaten to derail learning. It was found that insight into the sources of student resistance has helped instructors to become "less defensive and more supportive" (Sundt 2010; 282). Middendorf's (2015) finding reinforces the notion that emotional bottlenecks should not be regarded as problems in the classroom, but rather as "useful flags" (Middendorf 2015, 177) which indicate patterns of thought that may interfere with student learning.

Making expert habits of mind more explicit for the novice learner

The method of Decoding brings deeper levels of interpretation to the scholarship of teaching and learning and may be linked to broader frameworks of philosophical, sociological and psychological approaches. For instance, special attention has been brought to the interview technique (Miller-Young and Boman 2017) where researchers have detected the presence of themes such as the reconstruction and deconstruction of knowledge. As discussed and explained in the introduction of this article, these terms are interpreted using Pace's (2017) stance on "deconstructing" to explain and simplify the meaning of complex phenomena and thoughts.

In this regard, interviewees have highlighted the importance of the extent to which teachers help students understand, investigate and determine how implicit cultural assumptions, references, perspectives, and philosophical biases within a discipline influence the ways in which knowledge is constructed within it. It was found that the Decoding model serves to develop the capability to deconstruct such disciplinary thinking through generating new ideas or understandings. This method of deconstruction allows students to not only master a new set of mental operations, but also enables them to adopt the required knowledge practices and dispositions of professionals in the disciplines that they aspire to enter.

As mentioned earlier in this article, the habit of deconstructing knowledge allows complex processes and phenomena to be transformed into manageable chunks of information (Miller-Young and Boman 2017; Miller-Young 2015; Pettit 2017; Lee-Post 2019; Pace 2011; Schlegel 2004; Grim et al. 2004). Miller-Young and Boman's (2017) study found that knowledge construction involves the expert's ability to recognise patterns and connections amongst various pieces of information; examine problems from different points of view, and engage consciously with their surroundings (Miller-Young and Boman 2017). These habits of mind should be integrated into the classroom allowing students to "step back from the constructed narratives to deeper questions of interpretations and meaning" (Pace 2017, 125).

Miller-Young's (2015) self-study found that group dialogue during interviews generated deeper understandings of the disciplinary concept of reciprocity and states that expert thinking is "inclined towards an epistemology in which knowledge construction is never finished or complete" (Miller-Young 2015, 40). Similarly, Pettit (2017), Lee-Post (2019), Pace (2011), Schlegel (2004) and Grim et al. (2004) found that active participation amongst students generates new forms of questioning that appear to be powerful tools for reflection. Without precluding the importance of autonomous learning, such team effort facilitates disciplinary skill development (Schlegel 2004) and allows tasks to be skilfully analysed, dissected (Grim et al. 2004) and deconstructed.

Trans-disciplinary approaches and the T-Shaped learner

According to the University of the Western Cape (UWC) Charter of Graduate Attributes for the Twenty First Century (2018), one of the four holistic overarching and enabling attributes which characterises the Twenty First Century graduate is the "T-shaped learner". It is envisaged that this graduate should be able to have in-depth knowledge of their own respective field of study (vertical column of the "T"), yet should also have the proficiency to apply such knowledge across all diverse disciplinary and professional boundaries (horizontal column of the "T") to solve problems beyond their home discipline. Students are therefore required to think critically and apply their knowledge within unfamiliar contexts.

This review found that two shortlisted studies (Fischer 2018; Zhu et al. 2012) highlighted these attributes which became apparent through the Decoding interviews. One study posits that experts are able to apply a disciplinary concept such as "sustainability" [author's own quotation marks], across various subjects, depending on their level of interest. In addition, the study found that the modelling process (step 3) also enables debate and discussion amongst learners which enhances critical thought and that this could initiate a "feedback culture in the disciplines of sustainability science and beyond disciplinary boundaries" (Fischer 2018, 157). The study also concludes that DtD could be a valuable approach for transdisciplinary research. Similarly, Zhu et al.'s (2012) study incorporated metaphor-building exercises in the decoding process to facilitate the use of geologic time in various authentic world problems.

Synergies between threshold concepts and information literacy habits of mind

Three studies (Mohamed 2020; Miller 2018; Burkholder 2011) found that expert habits of mind may be directly aligned with information literacy ways of thinking and practices. Mohamed's (2020) study suggests that by integrating an additional step into the decoding model, critical literacies could be enhanced. The interview in Mohamed's (2020) study revealed that a strong synergy exists between expert habits of mind and the threshold concepts of the ACRL Framework (2016). The case shows that information literacy dispositions could be embedded within the disciplinary unconscious mind of the practitioner. Through modelling information literacy ways of being and thinking, Mohamed (2020) was able to assist students in the Business Finance module to overcome complex bottlenecks.

Similarly, this valuable insight was surfaced in Miller (2018) and Burkholder (2011). Burkholder (2011) discovered that by focussing on one bottleneck at a time, other obstacles in learning may surface in the process. Such places of liminality are: finding information for an assignment, annotating a bibliography, differentiating between different sources of information and refuting counter-arguments. These information literacy practices were elicited during

practice and feedback (step 4) where students were instructed to write a music history paper.

In addition, Miller's (2018) entire study is devoted to bringing tacit information literacy knowledge of the expert and disciplinary bottlenecks together. Her pilot project revealed complex themes pertaining to the ACRL Framework (2016) and found that the DtD model could be used to further develop critical literacies.

Additional insights

Moreover, all the included studies except for Verpoorten et al. (2017), attest to the fact that the DtD model has valuable impact on eliciting hidden challenges and for assisting learners to overcome thresholds in learning.

However, the researcher and reviewer noted that, although all the studies lauded the Decoding model for its significant contribution to teaching and learning, they placed huge emphasis on the importance of mental operations. Many studies lacked the holistic picture of teaching practices, which encompasses more than just extrapolating the mental models of the practitioner. Furthermore, the operations are not detailed enough to show how novice learners should transition to become expert thinkers.

None of these studies mention the degree of expertise that is required to exhibit significant mental operations. It may be inferred that the expert's experience and ingrained knowledge would determine the type and value of tacit knowledge that they hold and whether this is adequate enough to embed into transformed pedagogical practices in the classroom.

LIMITATIONS OF THE REVIEW

Due to the COVID-pandemic, the researcher and reviewer were unable to meet in person. Hence, all deliberations surrounding the verification of literature were restricted to virtual platforms such as Google Docs, Google Sheets, Zoom meetings and Whatsapp communication. This mode of collaboration may have limited the intensity and rigour of cross-checking during each phase of the review process.

Furthermore, the current study has been restricted to reviewing material published between January 2004 and December 2020. The researcher found a limited number of articles pertaining to research on the DtD model, which implies that this body of literature may not be saturated enough for an in-depth systematic review. This finding also implies that there is much scope for further research and development in this area of teaching and learning.

The majority of studies on the Decoding model were conducted in the USA where it was initially developed and tested. Only 2 studies were performed in a developing country (South Africa), but no research exists to corroborate that the model does have any impact on student

learning across other developing nations where education systems are vastly different. This may have skewed the current study's findings pertaining to the efficacy of the Decoding model on developing expert habits of mind.

IMPLICATIONS OF THE STUDY FOR HIGHER EDUCATION IN AFRICA

This nuanced approach to teaching and learning may have a profound impact on higher education as it aims to assist learners with disciplinary challenges by empowering them to think and behave as experts in their fields. It incorporates the theories that are advocated by Paulo Freire on critical pedagogy and is disruptive in the sense that it has the potential to decolonise the traditional ways of teaching and empower the student to develop expert ways of thinking. Underpinned by Threshold Concept Theory and transformative learning, the DtD model offers a framework which integrates all these theories that are student-centred, participatory and evidence–based.

As was discussed in the review, students are able to think flexibly and creatively, transferring and applying their learning from one context to new situations. This infers that their transformed perceptions show that such pedagogical approaches should be foregrounded in transformative teaching in South African classrooms. We argue that cognitive transformative pedagogy interventions such as the Decoding model have a reflective dimension which may be used for decoloniality. Within an African educational setting, this method could encourage students to reflect on inequalities and socio-political contexts, as many young scholars would want to speak about racialised, classroom-based forms of historical oppression. The model disempowers colonial teaching and assumptions that are indicative of unjust regimes by empowering the student to develop expert habits and new ways of thinking.

CONCLUSIONS

In conclusion, we can say that several fundamental aspects were highlighted through this systematic review. First, the study shows that the DtD model was used to prioritise the unlocking of expert mental operations. Although it was found that students do experience various and differentiated stages of liminality in learning, the interpretations of their own perceptions of the decoding process were omitted. The studies examined how the expert's ways of thinking could transform teaching practices and alleviate bottlenecks in the process, yet almost no surveys or focus groups were held with students to explore their own thinking and what exactly constitutes their individual blockages in learning. This is a huge gap in the literature and needs to be highlighted in future research.

Second, the reviewed articles showed that the researchers were able to extract some ways

of thinking that are relevant for future pedagogical practices. However, the 7-step process was not holistically applied in all case studies. As discussed earlier, only certain steps were used to extract expert dispositions and for their subsequent use in classroom settings. This infers that more research is needed to explore whether the steps are interconnected and explicable only in reference to the entire model, or whether it suffices to conclude that disciplinary thinking could also be successfully developed by the application of randomly selected steps. Nonetheless, for a complete and thorough implementation and evaluation of the model to occur, its different phases should best be explored over an extended period of time.

Third, although the DtD model is found to be promising, the linkages between it and Teaching and Learning theories have not been sufficiently explored. This paves the way for a much deeper investigation into the Decoding model in future research.

Moreover, one of the many ways in which the identified habits of mind were made explicit in student learning was to concretise abstract phenomena. It was found that teaching learners to visualise, specifically by using metaphors or analogies, would assist with grasping the meaning of complex terms and processes.

Furthermore, students may enter a state of liminality in their learning due to emotional blockages. As mentioned above, emotions cannot be translated in course content or lesson plans. These affective experiences should be given explicit attention and integrated into pedagogical practices.

It was also shown that the Decoding model serves to develop the capability to deconstruct disciplinary thinking through the generation of new ideas or understandings. The ability to recognise patterns and connections in texts and in different points of view allow students to "step back from the constructed narratives to deeper questions of interpretations and meaning" (Pace 2017, 125).

Certain studies also concluded that Decoding the Disciplines could be a valuable approach for transdisciplinary research where, in some instances, learners were encouraged to think beyond their home disciplines to solve complex problems.

It was found that, to a certain degree, a synergy does exist between the decoding model and information literacy. Three studies explored this intervention, concluding that some expert mental models are related to critical literacy practices. The Decoding model makes provision for this finding in the second step of the cycle.

This study was done using a systematic review process with clear, prescribed guidelines. The steps which were implemented served to find the most suitable body of articles which were selected and appraised. A thorough data extraction was conducted from each study. Only relevant and significant studies were included in the review. We conclude that our findings may

be valuable for researchers who may want to use our study as a springboard for future investigation into the application of the decoding paradigm in student learning.

NOTES

1. The researcher is in reference to Shehaamah Mohamed, Senior Librarian: Teaching and Learning, Library Services, UWC.
2. The reviewer is in reference to Professor Bayat, School of Business and Finance, EMS Faculty, UWC.

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