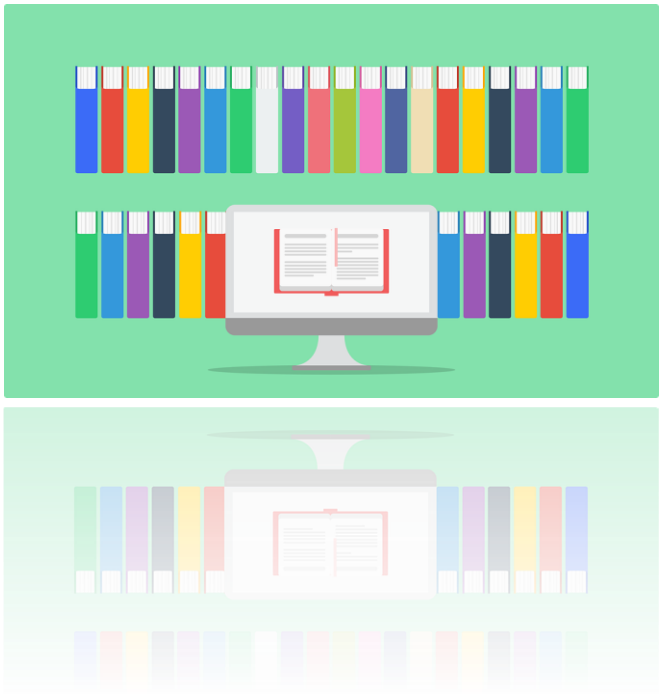
ANALYSING INFORMED LEARNING AT MAASTRICHT UNIVERSITY: A NARRATIVE REVIEW



Stefan Jongen, PhD[1,2], Jaro Pichel, MSc[1,2], Frederike Vernimmen-de Jong, LLM[1], Harm Hospers, PhD[2]

[1]Education & Support department, University Library Maastricht, Maastricht University

[2]EDLAB Institute for Education Innovation, Maastricht University.

Foreword

This paper has been written in the context of the endeavor to focus on learning analytics at Maastricht University (UM). It entails a narrative literature review, discussion points and recommendations as a foundation for further projects related to teaching and learning at UM. This paper specifically provides information for the university-wide project 'Information-Wise', which aims to assess the current state of information literacy skills at UM and develop an information literacy programme for students, with online modules that are both generic and discipline specific.

Authors are Stefan Jongen, Library information specialist, and Jaro Pichel, Library-EDLAB project leader "Learning in a changing information landscape". The review has been supervised by Harm Hospers (UM Vice dean and EDLAB director) and Frederike Vernimmen (manager Education & Support). Discussion points and recommendations have been formulated in close cooperation with Henrietta Hazen (coordinator Skills & academic support at the University Library) and Julie de Ronde (coordinator innovation at EDLAB).

EXECUTIVE SUMMARY

Learning and teaching should be at the forefront of innovation through the *informed* use of a wide range of evidence contextualised to the specific circumstances of the institution and discipline. Maastricht University (UM) puts emphasis on analysing learning and important 21st-century skill development, such as information literacy skills. Informed learning is a distinct way to approach information literacy in that it addresses the functional, situated and critical nature of learning to deal with information. However, we have limited insight to what extent informed learning practices occur. The aim of the present review is to answer the question how we can analyse informed learning at Maastricht University. More specifically, in what way can we collect data about the link between information and the learning process to receive insights for both teachers and students? The present paper reviews several studies, which described how to analyse information as part of the learning process.

RECOMMENDATIONS

In conclusion, these are the five most important recommendations for the UM regarding analysing informed learning:

1) Analyse to what extent the functional, situated, and critical approach of informed learning are practiced with a mixed approach,
2) Quantitatively analyse the issues related to information use within the learning process in a student population by using surveys and how teachers (faculty and library) perceive information in the learning process by using surveys,
3) Qualitative analyse how students and teachers deal with information in the learning process by using focus group,
4) Quantitatively analyse to what extend intended learning outcomes in course manuals meet information literacy standards,
5) Use both formative and summative assessment to measure information literacy skills and include the four levels of assessment, including level 4 (results). This level of measurement considers the big picture and long-term effects of instructions and should be taken into account if the UM wants to pursue a longitudinal approach regarding informed learning.

CONCLUSION

Data can thus be collected from several perspectives (e.g. institutional, teachers, and students). By collecting these data, we can increase the awareness regarding information literacy as part of the

learning process. In addition, these data can provide input for useful interventions to optimise information literacy education at the UM in order to provide students with one of the most essential skills for their future career.

INTRODUCTION

Learning is the process of acquiring new, or modifying existing, knowledge, behaviours, skills, values or preferences (Holt et al., 2015). Learning to learn is an important skill, as it is crucial in order to deal with high levels of uncertainty to adapt to new circumstances within the current society. Teaching staff, in collaboration with, instructional designers or instructional systems designers create instructional experiences which make the knowledge and skills acquisition more efficient, effective, and appealing (Merrill, Drake, Lacy, Pratt, & ID_2 Research Group, 1996). The process of instructional design consists of determining the state and needs of the learner, defining the end goal of instruction, and creating some "intervention" to assist in this transition. However, the current models, frameworks, and approach to understand learning in higher education seem rather inadequate. As Laurillard (2013, p. 12) notes "Academics have ambitious definitions for student learning. When asked to define the nature of learning in their subject area, they produce descriptions of high-level thinking, such as 'critically assessing the arguments', 'compiling patterns to integrate their knowledge', 'becoming aware of the limitations of theoretical knowledge in the transfer of theory to practice". Course descriptions tend to focus primarily on subject content that students will be learning. Because learning is not simply a product, but a series of activities the process itself is interesting as well. Developing skills and capabilities is as important as formal knowledge. In other words, *how* students approach their subject is as important as what they end up knowing (Laurillard, 2013). However, the problem is the limited information regarding the way students approach their learning and whether the learning process matches the intended learning outcomes of teaching staff in dealing with information. A potential solution is applying *learning analytics* in providing information regarding the learning experience. Learning analytics is generally defined as the measurement, collection, analysis of reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs (Learning and Academic Analytics, 2011).

LEARNING ANALYTICS ON PROBLEM BASED LEARNING PROCESSES AT MAASTRICHT UNIVERSITY

At Maastricht University (UM), the main purpose of education is to facilitate the integrated and professional development of the individual student. Learning revolves not around courses, but around students' academic and personal development (Maastricht University, 2016). The strategic agenda of Maastricht University notes (p. 13): "In the next years, attention will be paid to UM's internal quality assurance systems. Impact of innovations is going to be measured by making use of *learning analytics.* Detailed information will be collected on learning processes (such as learning styles and grades), in order to identify new ways of learning that are fit for new generations of students" (Maastricht University, 2016, p. 13). In other words, gaining insights into the learning process of students is

perceived as important by the UM. An important question is if and *how* it is possible to receive such insights in the process of students' learning by analysing quantitative and/or qualitative study data.

The learning process of students is interlinked with the aim of the UM to train students in self-regulated learning (SRL) skills (Maastricht University, 2016). Generally, SRL consists of three main components: metacognition, motivation, and behaviour / cognition (Vermunt & Verloop, 1999). The last component refers to learning strategies that assist the learner in the effective processing, use, and manipulation of information (De Smul, Heirweg, Van Keer, Devos, & Vandevelde, 2018). Nowadays, an important aspect of learning is dependent on effective information processing and the ability to cope with an increased volume of information (Cornford, 2002).

Importantly, the deliberate use of information is imperative in the learning process of students; students always engage with some type of information to enhance the learning experience. In this respect, the strategic roadmap of the University Library (UL) indicates that the UL aims to equip the entire UM community with skills required to foster successful students and is committed to developing and providing 21st century skills for a diverse community (Maastricht University Libary, 2017). "We contribute to the development of flexible learning pathways and identify and recognise diversity and the various ways in which students, lecturers and researchers want to learn – all of this in close cooperation with the faculties and the MUMC. For 2021, the Library envisages an emphasis on self-directed learning and constructive alignment in faculty education programmes and integration of digital skills in information literacy training" (Maastricht University Libary, 2017, p. 3). In other words, the UL commits to the challenge of providing students with important 21st century skills and supporting students who want to develop self-directed flexible learning pathways in close cooperation with the UM community and to constructively align these skills within faculty education programmes.

INFORMATION LITERACY

Thus, both the UM and the UL put emphasis on analysing learning and important 21st-century skill development. In order to push these development forward in higher education, learning and teaching should be at the forefront of innovation in learning through the *informed* use of a wide range of evidence contextualised to the specific circumstances of the institution and discipline (Lodge, 2016). In 1998, the American Association of School Librarian and the Association for Education Communications and Technology indicated six standards that librarians and teachers could use to describe information literature students.

The student who is information literate:

1. Accesses information efficiently and effectively

2. Evaluates information critically and competently
3. Uses information accurately and creatively

The student who is an independent learner:

4. Is information literate and pursues information related to personal interests
5. Is information literate and appreciates literature and other creative expressions of information
6. Is information literate and strives for excellence in information seeking and knowledge in general

These standards illustrate the relationship between information literacy and self-directed learning. Information literacy multiplies the opportunities for students' self-directed learning, as they become engaged in using a wide variety of information sources to expand their knowledge, ask informed questions, and sharpen their critical thinking (Association of College and Research Libraries, 2000).

In 2015, the Association of College and Research Libraries (ACRL) board revised the Information Literacy Competency Standard for Higher Education as a response to the changing information environment (Association of College Research Libraries, 2015). The ACRL framework highlights the importance of the shared responsibilities of faculty teachers and librarians in creating a cohesive curriculum for information literacy. In this way, the framework also reflects the necessity to align information literacy training constructively with faculty curricula. Faculty teachers have a great responsibility in designing curricula and assignments, which foster enhanced engagement with information and scholarship within disciplines; librarians have a great responsibility in identifying core ideas within their own knowledge domain that can extend learning for students. The framework expanded the definition of information literacy to emphasis the dynamic, flexible, individual growth, and community learning as characteristics of the link between information and learning. Information literacy is defined as: "*..the set of integrated abilities encompassing the reflective discovery of information, the understanding of how information is produced and valued, and the use of information in creating new knowledge and participating ethically in communities of learning"*

Furthermore, the framework approaches information literacy from an affective, attitudinal, and valuing dimension of learning as reflected by six frames: (1) Authority Is Constructed and Contextual (2) Information Creation as a Process (3) Information has Value (4) Research as Inquiry (5) Scholarship as Conversation, and (6) Searching as Strategic Exploration. In addition, it adds thresholds concepts and meta-literacy in defining information literacy (Association of College Research Libraries,

2015). These dimensions and concepts are elaborately described in a recent review about the changing role of information literacy skills in higher education (Pichel, Jongen, & Hospers, 2018)).

INFORMED LEARNING

Informed learning is a distinct way to approach information literacy. It addresses its situated and critical nature compared to the traditional approach of teaching information literacy as a discrete skill (Bruce & Hughes, 2010). Information literacy can be categorized in a functional, situated, or critical approach (Lupton & Bruce, 2010). The functional approach to information literacy assumes that students will be able to apply information skills acquired in higher education within the various settings in which they learn. The situated approach emphasizes the role of information in specific contexts (e.g. disciplinary or professional setting), while the critical approach aims to make students aware of social and political aspects of information productions and use. The functional approach is most often utilized in information literacy efforts in higher education, but does not account for the situated and critical perspective of information literacy (Maybee, 2018).

The central idea of informed learning – in a functional, situated, and critical approach - is that students should learn to use information in the context of learning about a topic. By adopting an informed learning approach, information literacy will be merely positioned within the disciplinary classroom. Advancing informed learning in higher education requires that academic librarians, with their knowledge of how students use information to learn, collaborate with teachers to integrate information literacy into course curricula. Informed learning has three main principles: 1) informed learning builds on learners' current informed learning experiences 2) informed learning promotes simultaneously learning about disciplinary content and the information using process 3) informed learning enables learners to experience using information and subject content in new ways (Bruce & Hughes, 2010). Several characteristics of informed learning are 1) engaging with information (i.e. awareness of different ways of using information), 2) subject-content information (i.e. focus on knowledge creation and diverse forms of information, such as textual, visual, and auditory), and 3) pedagogy (i.e. active learning techniques, such as collaboration and independent learning, problem-solving, evidence-based practices, and independent research (Bruce & Hughes, 2010). Like other contemporary approaches for designing learning environments, informed learning tends to employ active learning techniques, such as independent learning, problem-solving, and evidence-based practice (Walker, 2003). The pedagogy of informed learning fits well within the problem based learning philosophy of UM, in which students actively and collaboratively try to solve problems related to the course content (Schmidt, 1983).

LEARNING STYLES AND STRATEGIES IN DEALING WITH INFORMATION

An important aspect of instruction is to understand the difference between learning styles of teachers and students, as most teachers adopt a style of teaching related to their own learning style. However, student might apply different learning styles in dealing with information. To be aware of one's own learning style can support in the learning process and can avoid misunderstanding between instructor and student. *Learning styles* are defined as a combination of cognitive, effective, and psychosocial behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (Curry, 1981). Learning styles define learning strategies to a certain extent. The effective use of different learning strategies is an important part of self-regulated learning (De Smul, Heirweg, Van Keer, Devos, & Vandevelde, 2018). Nowadays, an important aspect of learning is dependent on effective information processing and the ability to cope with an increased volume of information (Cornford, 2002). However, we have limited insights whether student use and switch between various learning strategies in effectively dealing with information.

LEARNING ANALYTICS IN SYSTEMS

Although the Learning Management System (LMS) and the Student Information System (SIS) are often indicated as the most essential sources for analysing data, the learning analytics research community has often tended to draw data from elsewhere (Sclater, 2017). The majority of studies in a review of 60 publications used data from adaptive learning systems, intelligent tutoring systems, or web-based courses held outside the LMS and without reference to demographic or other data from the SIS (Chatti, Dyckhoff, Schroeder, & Thüs, 2012).

Analysing learning by obtained data from the LMS and SIS has many obstacles. A significant problem is that students may carry out many of their learning activities outside the monitored and recorded confines of the institution's LMS. Students are increasingly likely to study content information that is freely available on the Web and to use social media tools outside the classroom. Another significant problem is that most institutions do not use their LMS in a consistent way; many of their courses may make little use of online tools and resources within the LMS. Thus, data on student's learning may be limited and only of use in courses were LMS use is core part of the learning design (Dlalisa, 2017). In conclusion, the low validity of learning analytics within systems, such as the LMS and SIS, to analyse learning is a major drawback. Learning analytics within systems has – until now - limited value in assessing learning in small-scale education at Maastricht University. In the future, data of LMS could be used to track activities related to learning behaviour, but at this point these systems are limited to analyse the learning process itself. Thus, other approaches regarding

analysing learning (e.g. analysing informed learning) seem to be more appropriate for small-scale problem-based learning.

PROBLEM STATEMENT

Ideally, curriculum and course designers take the deliberate use of information into account when developing courses and expanding the learning experience of students. Even if they do, we have limited insights in the learning behaviour of individual students. In addition, we have limited insights whether intended learning outcomes of teachers and instructional designers match the expected learning outcomes of students. Furthermore, students may have limited awareness of their learning behaviour. A solution could be to collect data to enhance the learning experience of learners. However, less is known about *what* kind of data could or should be collected and analysed continuously to measure and enhance a successful learning experience related to information use. However, there is a need to analyse and evaluate informed learning behaviour of students and to analyse whether discrepancies occur between the intended learning outcomes of course designers and the actual learning outcomes of students related to the link between the use of information and self-directed learning.

AIM OF THIS REVIEW

The aim of the present review is to answer the question how we can best analyse informed learning at Maastricht University in order to enhance the learning experience and study success of students. More specifically, in what way can we continuously collect data in a structured way about the link between information and the learning process to receive insights for both teachers and students? How do teachers and students perceive informed learning and how can we provide recommendations and feedback to teachers and students regarding the intended learning outcomes and students' learning? More specifically, the first part of this review focuses on how to analyse informed learning and the second part about how to analyse learning styles and strategies.

ANALYSING INFORMED LEARNING AT FACULTY PROGRAM LEVEL

The ACRL board defined a framework which could be useful as an inventory to approach faculties regarding informed learning (Association of College Research Libraries, 2015). The framework uses six frames, each consisting of a concept central to information literacy. These six concepts are: 1) Authority Is Constructed and Contextual 2) Information Creation as a Process 3) Information has Value 4) Research as Inquiry 5) Scholarship as Conversation 6) Searching as Strategic Exploration. It is suggested by the ACRL to use this framework as a collaboration among librarians, faculty, and other institutional partners to redesign instruction sessions, assignments, courses and curricula. The framework defines several questions, which can be helpful to start the conversation with faculties regarding informed learning:

- "What are the specialized information skills in your discipline that students should develop, such as using primary sources or accessing and managing large data sets?"
- "What information and research assignments can students do outside of class to arrive prepared to apply concepts and conduct collaborative projects?"
- "What kind of workshops and other services should be available for students involved in multimedia design and production?"
- "In your program, how do students interact with, evaluate, produce, and share information in various formats and modes?"
- "How might you and a librarian design learning experiences and assignments that will encourage students to assess their own attitudes, strength/weaknesses, and knowledge gaps related to information?"

Course syllabi analysis

One way to analyse *informed learning* is to review course syllabi. Reference librarians (i.e. librarians who recommend, interpret, evaluate and/or use information resources to support users with specific information needs) employ syllabus reviews to create workshops and other library instruction activities that align with the information literacy learning outcomes articulated by instructors and departments. A recent review of four conducted syllabus reviews evaluated the content of a large sample of syllabi (n= 1153) and generated a rich data set about the nature of teaching and learning (Stanny, Gonzalez, & McGowan, 2015). The most recent of these four syllabus reviews developed inventories of courses that address information literacy learning outcomes and 21st century skills while revisiting questions about syllabus quality and the culture of teaching and learning addressed in previous reviews. This review also identified courses with Student Learning Outcomes (SLOSs) and

assignments that aligned with information literacy standards (articulated by the Association of College and Research Libraries (2000)). Outcomes of the review was that SLOs aligned with information literacy standards appeared on 58.5% of the syllabi (674 syllabi described one or more course SLOs that aligned with one or more ACRL information literacy standards). In addition, 683 (59.2%) of the syllabi identified an assignment that aligned with an information literacy SLO (regardless of whether the instructor described an information literacy SLO on the syllabus). The paper provides rubrics, which are useful to assess informed learning (see appendix 1).

ANALYSING INFORMED LEARNING AT SKILLS COURSE LEVEL

Assessment of information literacy instruction is essential to demonstrate the efficacy of the services to university stakeholders (Anderson, 2015). The ACRL framework (2015) places greater emphasis on student engagement with information (e.g. questioning, collaboration, and conversation), while most of the current information literacy assessment supports the former ACRL standards (Association of College and Research Libraries, 2000). The framework suggests shifting the assessment of specific discrete skills towards a focus on the learning process and engagement with information concepts. In other words, current practices focus on specific learning outcomes identify in the ACRL standards, while the ACRL framework puts larger emphasis on a general critical disposition towards information in the disciplinary context. This in turn will require addition assessment strategies to support deeper engagement with the learning process of students.

Anderson (2015) discussed the new ACRL framework as a new way of looking at information literacy in terms of assessment. Both summative assessment (i.e. assessment in providing important information *as* learning of a completed session or course) and formative assessment (i.e. assessment meant to contribute to the learning process) are needed to measure the use of information in the learning process. Assessment tools, such as guided group discussions, online discussion boards, and web 2.0 technologies could be used as formative assessment. In guided group discussions, both notes and observation of instructors and discussion audits and logs can collected, coded, and analysed qualitatively to provide data for assessment of library services. Moreover, online discussion boards are commonly used for formative assessment of student learning. Lastly, web 2.0 tools (e.g. Facebook, blogs, and Twitter) could be used for assessing instructions regarding information literacy.

A recent systematic review described and compared outcome assessment of information literacy in undergraduates (Erlinger, 2018). See Table 1 for an overview of multiple assessment methods. Erlinger (2018) employed two frameworks for the assessment types: formative (assessment during instruction) versus summative (i.e. assessment after learning is complete) and Kirkpatricks's

Table 1: Strength and weaknesses of assessment types

Type of assessment (SUM or FOR, 1-4*)	**Strengths**	**Weaknesses**
Surveys (SUM, 1)	Ease of administration; ease of scoring and comparison; good measure of perceived self-efficacy; low cost; quick to administer; useful feedback to instructors.	They do not measure learning; students often overestimate their own skills; they focus on intentions not behavior; students may tell us what we want to hear; they often provide little depth or detail in responses.
Focus groups (SUM, 1)	ability to ask follow-up or clarification questions; ability to collect data from several participants at once; the generation of rich descriptive data; can provide unexpected results not accounted for in other forms of assessment	require a great deal of time to administer; difficult to synthesize and code results; require training for good facilitation; learners may be uncomfortable expressing true opinions and tell us what we want to hear
Objective tests – locally developed (SUM or FOR, 2)	ease of administration; ease of grading; low cost; efficient assessment of a large number of students; generation of easily reportable numeric data; familiarity and comfort on the part of administrators and stakeholders; high reliability.	lack of authenticity; do not measure higher-order skills; can be time-consuming to create; measure recognition rather than recall; oversimplify concepts; usefulness can be threatened by teaching to the test; issues of vocabulary and culture can interfere
(CATs) and Performance Measures (FOR, 2)	immediate feedback; contributions to learning; ability to capture higher-order skills; valid data; giving students a realistic picture of skill set while there is still time to adapt; quickness of administration; acting as "assessment for learning"; low cost	difficult to measure, code, and quantify; information gathered is very broad; have limited generalizability to other settings; can be time-consuming to create
Authentic Assessment (SUM and FOR, 3)	contextualization of assessment; high validity; measurement of higher-order skills; demonstration of behavior change; easily aligned with existing instructional goals; account for different learning styles; provide direct evidence of learning; students know the expectations in advance; foster motivation and engagement	very time-consuming for students to produce and for instructors to score; require high degree of faculty collaboration; difficult to determine how students approached the problem and if they received outside help; require the development of clear grading criteria or scoring can be subjective and unreliable
Rubrics (Flexible tool)	consistency in scoring; efficiency in scoring; the development of a set of agreed-upon learning values; encouragement of meta-cognition and self-reflection; direct and meaningful feedback.	challenging and time-consuming to create and norm; training required for use; reflect the product, not the process

Standardized Instruments (SUM, 2)	do not require local development; use a variety of formats and scenarios; are often more authentic than locally developed tests; are considered valid; useful for establishing a campuswide baseline; useful for starting conversations with stakeholders	high cost of purchase, intimidating to both faculty and students; difficult to recruit students; difficult to interpret data without statistician assistance; difficult to adapt for students with disabilities; lag behind development of research tools and related software; not well suited to assessing at classroom level

CAT = Classroom Assessment Techniques, * SUM = Summative assessment, FOR = Formative assessment; number 1 to 4 refer to the levels of Kirkpatrick, with level 1 = reaction, level 2 = learning, level 3 = behavioural, level 4 = results

four levels of assessment (Kirkpatrick, 2009). These four levels are: 1) Reaction: Did students like it?, 2) Learning – Did students get it?, 3) Behavioural – Can students do it?, and 4) Results – does it matter?

Mixed-method approach

A recent study designed an assessment, which could determine the impact of a course-integrated model of library instructions on students' learning and achievement (Squibb & Mikkelsen, 2016). The project and curriculum was called *Teaching Research and Information Literacy* (TRAIL). Writing faculty introduced the students to content about the research process and information literacy via activities, readings, tutorials, and reflections before students had classroom instructions by a librarian. They used a mixed-method approach to assessment, using both qualitative and quantitative data representing indirect and direct evidence of student outcomes. Data collected included student reflections (TRAIL only), faculty debriefs (TRAIL faculty), final papers (TRAIL and non-TRAIL), final course grades (TRAIL and non-TRAIL) and grand point average (GPA) at the end of the first semester (TRAIL and non-TRAIL). Quantitative data were collected by rubrics, created by librarians (see appendix 2). The rubrics quantified students from score 1 (*Marginal)* to *Emerging (*score 2), to *Developing* (score 3), and to *Advanced* (score 4). The quantitative design evolved in collaboration with a Principal Research Analyst, leading to additional knowledge for librarians about research designs.

Overall, the evaluation of student reflections, final papers, and faculty observations showed a positive relationship between the TRAIL curriculum and student learning. More specifically, student reflections indicated that over 50% scored *Advanced* or *Developing* for all six criteria. These criteria were: 1) academic research changes, 2) source selection, 3) challenges, 4) attitude, 5) transferability, and 6) think like a researcher. In addition, faculty members of the writing program (MWPs) observed student learning outcomes. Four out of five MWPs thought that TRAIL students were thinking and

writing more like researchers compared to students in previous introductory composition courses. However, two of them did not observe TRAIL students to better incorporate evidence from several viewpoint compared to students they had taught in the past. This evidence implies that students competencies related to incorporation of evidence from several angles required more instructional time and attention. Lastly, it should be noted that even tough findings point to the benefit of the TRAIL curriculum on student learning, it did not show evidence of a positive correlation with student's GPA (Squibb & Mikkelsen, 2016).

SELF-REGULATED LEARNING AND INFORMATION

Self-regulated learning (SRL) skills development is an important part of studying at UM. Generally, SRL consists of three main components: metacognition, motivation, and behaviour / cognition (Vermunt & Verloop, 1999). The last component refers to learning strategies that assist the learner in the effective processing, use, and manipulation of information (De Smul et al., 2018). Teachers can instruct the use of learning strategies by implicit and explicit instructions (Kistner et al., 2010; Kistner, Rakoczy, Otto, Klieme, & Büttner, 2015). An implicit instruction means that teachers prompt student to use strategic behaviour without addressing it or when teachers act as role model without informing the learning about the significance of this behaviour. Explicit instructions mean that teachers also explicitly explain and/or demonstrate *why, how,* and *when* it is important to use a strategy and how it can improve students' performance. Teachers rarely integrate SRL in their classroom because of difficulties with implementing theory into practice (Kistner et al., 2010; Spruce & Bol, 2015).

Analyse information use in learning styles

A definition of *learning styles* is a combination of cognitive, effective, and psychosocial behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (Curry, 1981). No consensus about an accepted method to assess individual learning styles currently exists, but several potential scales and classification are in use (Romanelli, Bird, & Ryan, 2009). In their review of 2009, the authors outline four learning style measurements (Romanelli et al., 2009). These tools could be used to analyse learning styles that students use.

The first measurement tool is the Learning Style Inventory Instrument (LSI). LSI is derived from an experiential theory and model of learning (Kolb, 1984). In this experiential model, learning is viewed as a continually recurring problem solving process in the four-stage cycle: 1) concrete experiences are followed by 2) reflective observations. These observations can lead to the formulation of 3) abstract concepts and generalizations, that in turn, lead to 4) active experimentation to test particular

hypotheses. Learners are described as divergers, convergers, assimilators, or accommodators based on learner's preferences in terms of concrete vs abstract, and action vs reflection (Kolb, 1993).

The second instrument is the Learning Style Questionnaire (LSQ), The LSQ provides 80 statements, which have to be answered with *agree* or *disagree*. The answers will lead to a distinction into one of four distinct types of learners: 1) activists (i.e. learn primarily by experience), 2) reflectors (i.e. learn from reflective observation), 3) theorists (i.e. learn from exploring associations and interrelationships), and pragmatics (i.e. learn from doing things with practical outcomes) (Honey & Mumford, 2000).

The third assessment of learning styles is the Canfield Learning Style Inventory (CLSI). The CLSI provides 30 multiple-choice questions with four answer possibilities. Learning is described in four dimensions: 1) conditions for learning, 2) area of interest, 3) mode of learning, and 4) conditions for performance (Canfield, 1992).

The fourth instrument is the Index of Learning Survey (ILS). The survey consists of 44 questions with two answer possibilities. Learners are categorized in four dichotomous areas: preference in type and mode of information perception (sensory vs intuitive; visual vs verbal), approaches to organizing and processing information (active vs reflective 1), and progress towards understanding (sequential vs global) (Felder & Silverman, 1988).

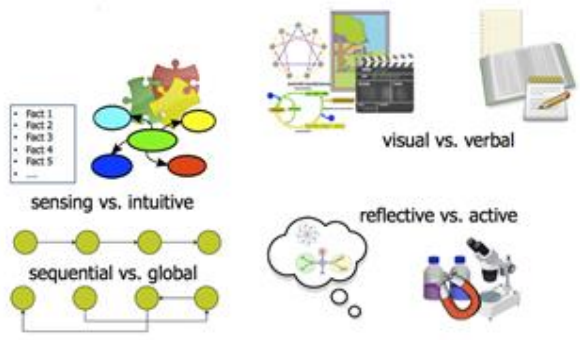


Figure 1: Learning styles (Felder & Silverman, 1988)

Analysing information use in learning strategies

Learning styles define learning strategies to a certain extent. A recent extensive review critically reviewed ten different learning strategies (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013). These ten techniques were evaluated on their utility by assessing their benefits to generalize across four categories of variables. These variables are learning conditions (e.g. learning environment, studying alone or within a group), student characteristics (e.g. age, ability, level of prior knowledge), materials (e.g. simple concepts to complicated science texts), and criterion tasks (e.g. different

Table 2. Learning Techniques

Technique	Description
1. Elaborative interrogation	Generating an explanation for why an explicitly state fact or concept is true
2. Self-explanation	Explaining how new information is related to known information, or explaining steps taken during problem solving
3. Summarization	Writing summaries of to-be-learned texts
4. Highlighting/underlining	Marking potentially important portions of to-be learned materials while reading information
5. Keyword mnemonic	Using keywords and mental imagery to associate verbal materials
6. Imagery for text	Attempting to form mental images of text materials while reading or listening
7. Rereading	Restudying text material again after an initial reading
8. Practice testing	Self-testing or taking practice tests over to-be-learned material
9. Distributed practice	Implementing a schedule of practice that spreads out study activities over time
10. Interleaved practice	Implementing a schedule of practice that mixes different kinds of problems, or a schedule of study that mixes different kinds of materials, within a single study session

Adapted from (Dunlosky et al., 2013)

outcome measures, such as memorization, problem solving, and comprehension). For this review, we focus on the learning techniques in relation to materials, as these are the main indicator of the use of information sources. See Table 2 for an overview of learning strategies, adapted from Dunlosky and colleagues (2013).

The authors qualified practice testing, distributed practice, rereading, elaborative interrogation, and self-explanation as positive indicators of dealing with materials. Summarization was qualitied as potentially positive with insufficient evidence, and highlighting, the keyword mnemonic, image use for text learning were indicated as 'qualified', meaning that the technique yielded some positive effects under some conditions / groups, but not others. When taking all criteria (i.e. learning conditions, both practice testing and distributed practices were rated as high utility learning techniques, because learners with different characteristics have been shown to enhance performance across many criterion tasks and educational context. Elaborative interrogation, self-explanation, and interleaved practice were ranked to moderate utility. Their benefits do generalize across some

variable, but the evidence for their efficacy was limited. The other five techniques (i.e. summarization, highlighting/underlining, keyword mnemonic, imagery use for text learning, and rereading) were rated – in general - as low utility.

DISCUSSION

The aim of the present review is to describe how we can analyse informed learning at Maastricht University. A review of the literature indicated the complexity of analysing learning behaviour. Many disciplines, such as learning analytics, learning sciences, learning design, educational design, and educational psychology are investigating the beneficial use of analysing learning. Common ground is that it is important for institutions, teachers, and students to get insights into learning behaviour. Informed learning can be analysed at different levels (e.g. institutional, programme, and course level) and from different perspectives (e.g. institutional, teacher, and student).

By using the *informed learning* theory, information literacy education is approached differently. While information literacy is often addressed in a functional way (i.e. teaching information literacy as a discrete skill), the situated and critical approach are less taken into account (Bruce & Hughes, 2010; Maybee, 2018). The quality of teaching information literacy and the importance of the information literacy skill will increase by teaching this skill in constructive alignment with specific disciplinary contexts (i.e. situated approach), increasing awareness about social and political aspects of information and using information in a new way (i.e. critical approach). These aspects should be part of and linked to the individual learning process of students (Maybee, 2018).

In order to have an overview of informed learning practices, a mixed approach (i.e. both quantitative and qualitative data) should at best be followed as the combination of these data provide valuable information regarding the analysis of informed learning. For example, a recent study used rubrics (see Appendix 3) and GPAs as quantitative data, and questionnaires for faculty members as qualitative data representing both direct and indirect evidence of student learning outcomes (Squibb & Mikkelsen, 2016).

Moreover, qualitative data can be obtained from program directors and faculty teachers. At the faculty level, the ACRL framework (Association of College Research Libraries, 2015) provides highly useful questions to be asked in focus groups to collect qualitative data regarding information literacy training as part of the learning process. In addition, a survey could reach a larger group of faculty teachers in providing additional qualitative data. In addition, a course syllabi analysis would provide highly useful information to collect data regarding the intended learning outcomes of teachers with

respect to information skills. A recent paper described several reviews which performed several course syllabi analyses to assess the intended learning outcomes (Stanny et al., 2015). Approximately 60% of learning outcomes aligned with information literacy standards. In addition, almost 60% of the course manuals provided an assignment that aligned with the learning outcomes. Thus, an analysis of course manuals would provide a rich-data set regarding the status-quo regarding intended learning outcomes and assessment at the UM. The core rubrics appendix 1 can be used as a guideline.

At a skills course level, is it highly important to follow a mixed-approach in collecting both qualitative and quantitative data. Data should be collected based on both summative and formative assessment (Anderson, 2015). Summative assessment is taken into account with surveys, focus groups, objective tests, authentic assessment, and standardized assessment; formative assessment with objective tests, CAT / performance measures, and authentic assessment (Erlinger, 2018).

All these measurements have several advantages and disadvantages (see Table 1). These should be taken into account to analyse data regarding information practices. Overall, an advantage is that most assessment take a different level of assessment into account: surveys and focus groups assess reactions (level 1); objective tests, CAT/performance measures, standardized instruments assess learning (level 2); authentic measurements assess behaviour (level 3). However, none of these tests assess results (level 4) (Kirkpatrick, 2009). The latter level considers the big picture and long-term effects of instructions. These attempts to determine whether the instruction had any lasting effect on the life of students. If the UM wants to pursue a longitudinal approach regarding information literacy education, level 4 assessment should be taken into account.

An important aspect of teacher instructions is to be aware of difference between learning styles and students. Most teachers might adopt a teaching style related to their own preferred learning style. Students might apply different learning styles in dealing with information. Several instruments are available: the Learning Style Inventory Instrument (Kolb, 1993), the Learning Style Questionnaire (Honey & Mumford, 2000), the Canfield Learning Style Inventory (Canfield, 1992), and the Index of Learning Survey (Felder & Silverman, 1988). These instruments could be used for both teachers and student to collect data regarding preferred learning styles in dealing with information.

Information processing is an important part of self-regulated learning (SRL), as it is related to the behavioural/cognitive element of SRL (De Smul et al., 2018). Generally, teachers rarely integrate explicit instructions regarding SRL in their classroom because of difficulties with implementing theory into practice (Kistner et al., 2010; Spruce & Bol, 2015). It is of utmost important that teachers do learn how to explicitly instruct all components of SRL (De Smul et al., 2018), including the use of information in self-regulated learning behaviour.

For students it would be highly beneficial to be aware how they deal with academic study materials and how to intervene if necessary. These learning techniques are most effective in dealing with materials: practice testing, distributed practice, rereading, elaborative interrogation, and self-explanation (Dunlosky et al., 2013). Data could be collected – with surveys or focus groups – regarding the use of these learning techniques in dealing with information. However, it should be noted that in general practice testing and distributed practice were qualified when all criteria (i.e. learning conditions, student characteristics, materials, and criterion tasks) into account, both practice testing and distributed practices were rated as the highest utility learning techniques (Dunlosky et al., 2013). In addition, it is important to acknowledge that a self-regulated learner should be able to adapt learning strategies with regard to specific learning outcomes in specific courses.

We have to be careful in the practical implications and conclusions of analysing learning and in particular learning styles. Potentially analysing learning styles and strategies should be aimed to increase awareness about the use of an individual's learning styles and strategies. When these styles or strategies are maladaptive for a specific course, interventions could be made to change the learning behaviour. However, there is no such thing as a 'best' learning style. A recent invited comment indicated many problems with the notion of learning styles (Kirschner, 2017). First, people cannot simply be clustered into specific and distinct groups. Most differences between people on a particular dimension or continuous and not nominal. Secondly, the psychometric qualities (e.g. validity and reliability) of learning style instruments are rather low (Coffield, Moseley, Hall, & Ecclestone, 2004). An often-used measure is self-report, and often learners are unwilling or unable to accurately report their learning styles. In addition, self-reported preferred way of learning is low predictive validity for the way people learn most effectively. In other words, self-reports of learning do have a low correlation with objective measures of learning. In addition, the self-reported preferred way of learning is often a bad predictor of the way people learn most effectively.

By analysing information in relation to learning, academic librarians can also determine their gaps in knowledge and abilities needed to collaborate with others to integrate information literacy into courses using an informed learning approach. In order to collaborate between academic librarians and faculty teachers, focus should be on gaining knowledge and abilities to advance informed learning (Maybee, 2018). Focus should be put on I) developing a thorough understanding of informed learning. II) being aware of current trends of information literacy. III) understanding teaching and learning theories and models and these may align with informed learning, instructional design models, and assessment practices for analysing learning of students related to using information as well as course content and IV) developing excellent communication skills to collaborate with faculty teachers to

cultivate shared goals on the advancement of content-focused learning through engagement with information.

The current review does not address the use of systems to analyse learning. since the Learning Management System (LMS) and the Student Information System (SIS) show ample obstacles until now. Further studies should also involve an exploration of possible automated sources (like assessment tools, online group discussion boards and other web 2.0 technologies) for analysing quantitative study data in order to set up a continuous monitoring and feedback program in order to enhance the learning experience and study success of students. In this respect the new LMS might offer unknown possibilities as well. In addition, it could be interesting to explore whether Artificial Intelligence techniques (such as, data mining, text mining, and natural language processing) could be any added value to analysing learning processes.

In summary, it is highly advised to collect both quantitative and qualitative data regarding informed learning based on the evidence reviewed in the present paper. The five most important recommendations for the UM regarding analysing informed learning are:

1) Analyse to what extent the functional, situated, and critical approach of informed learning are practiced with a mixed approach
2) Quantitatively analyse the issues related to information use within the learning process in a student population by using surveys and how teachers (faculty and library) perceive information in the learning process by using surveys
3) Qualitative analyse how students and teachers deal with information in the learning process by using focus group
4) Quantitatively analyse to what extend intended learning outcomes in course manuals meet information literacy standards
5) Use both formative and summative assessment to measure information literacy skills and include the four levels of assessment, including level 4 (results). This level of measurement considers the big picture and long-term effects of instructions and should be taken into account if the UM wants to pursue a longitudinal approach regarding informed learning.

Data can be collected from several perspectives (institutional, teachers, and student). At the UM, it is vital to collect data regarding the students' perspective, as education at the UM focus on academic and personal development. In addition, students should develop a sense of responsibility and ownership of their education. By collecting these data, we can increase the awareness regarding information literacy as part of the learning process. In addition, these data can provide input for useful

interventions to optimise information literacy education at the UM in order to provide students with one of the most essential skills for their future career.

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APPENDICES

Appendix 1:

Table 1. Core rubric for a syllabus review (required components and 'best practice' components).

Required components
Course number
Course title
Semester and year offered
Instructor(s) Name(s)
Contact information
Office number *or*
Office telephone *or*
Email address *or*
Web address (eLearning or faculty web page for course)
Office hours
List of required texts, recommended texts and readings
Course description from catalogue
Course student learning outcomes (SLOs) identified
Course SLOs written in *active language* and describe student behaviours or student work that could be directly measured
Topics covered in the course
Exams and grading. Describe how the instructor will evaluate student work in the course. Describe required exams and assignments and how these will be evaluated and weighted to compute the final grade in the course
Statement about proctored exams (required only for courses with online exams)
Attendance policy (eLearning: participation element is a part of the grade, policies about logging onto the class site regularly)
Statement of University academic conduct policy/plagiarism policy
Notification of use of turnitin (required only if instructor has written assignments and plans to use turnitin to evaluate originality of student writing)
Statement about assistance for students with special needs (ADA statement). Must include contact information for the campus ADA office (link to website, telephone number)
Emergency planning information for course continuity (e.g. weather, campus epidemic)
Calendar of important events (schedule of required readings, assignment due dates, exam dates, etc.). Dates can be identified as tentative dates and/or subject to change
'Best practice' components
Class meeting time and location (both must be present; eLearning courses are automatically present)
ISBN number of each required textbook
Instructor goals for the course or description of the role of the course in the programme or description of how the course will prepare students for tasks encountered in other courses
Introduction of instructor/description of professional background
Description of software or technology skills required for the course or description of study strategies that will help students succeed in the course. Includes activation and use of (institution omitted to maintain the integrity of the review process) email account as a technology skill. Does not include the use of laptops in class unless these must run a specialised software used for course activities
Assistance to all students: Strategies for success in the course; sources for assistance made available to all students (Writing Lab, tutoring). May include reference to hand-outs, extra problems, etc. that students can access in eLearning or on the web. Not mere encouragement to students to visit the instructor during office hours or ask for assistance or mere reference to technical skills needed
Instructor-established policies for the course (acceptance of late work; permission to make up a missed exam; procedures to request extensions of deadlines or arrange alternate exam dates when conflicts arise with official University functions). May also include

(*Continued*)

classroom behaviour policies (use of laptops in class, cell phones, eating, sleeping, face-to-face civility matters)
Expectation for classroom decorum/behaviour/civility. In eLearning courses: expectations for decorum in online discussions, email, etc. In face-to-face classes, policies about laptop use during class
Calendar includes reminders of key University deadlines (last day to withdraw with an automatic W) and provides feedback on graded work before these deadlines
Descriptions of specific projects. Any reference to a specific assignment or project beyond the weight it receives in final grade computation. May include reference to additional information that will be provided in a separate hand-out. (Note: Must be separate from references to projects in the Exams and Grading weights or course calendar sections.)
Grading rubric(s) for assignments provided in the syllabus (either a grading key or formal rubric)
Reference to use of a rubric for grading an assignment (rubric is provided on website, as a hand-out, etc., apart from syllabus)

Table 2. Comparison of criteria used to evaluate active learning, student engagement and use of HIPPs (2011 and 2013 reviews).

Evidence for high-impact practices in active learning and student engagement (2011 rubric)
Include assignments or activities that help students develop strategies for regulating their own learning
Align instructional practices with students' prior knowledge and cognitive ability
Prompt students with open-ended, provoking questions during in-class discussions or online-threaded discussions
Require students to make presentations during class or online
Require students to work with other students either in- or out-of-class on projects or presentations; explicit mechanism in place to evaluate team skills and contributions of each student to final project
Using a variety of teaching techniques including games, debates, skits, films, experiments, role playing, stories and higher order thinking activities (may supplement rather than replace lecture)
Require multiple drafts of written papers and assignments (e.g. sequence of assignments that build to a final large project and provide feedback so students can improve work)
Syllabus describes required activities in which students mentor, tutor or teach other students (e.g. a peer review as a required activity/assignment associated with a written paper)
Work with students on research projects or other activities outside of course or programme requirements
Syllabus includes a study abroad or travel component (e.g. class travels to other locations as a group)
Syllabus describes expectations for an independent study
Syllabus describes a community-based project, community service or volunteer work as a graded assignment
Syllabus includes attendance or participation in one or more cultural performances (lectures, theatre, concerts, museum shows.) as a graded element
Include diverse perspectives (different races, religions, genders, political beliefs, etc.) in class discussions and written assignments
Scoring criteria (2011)
Evidence absent
100% lecture-oriented class
Lecture from the assigned text only
Minimal evidence of student engagement
Recommend students form study groups
Assign group projects with no form of peer evaluation included
Rote homework assignments (busy work)
Suggest that students mentor, tutor or teach other students
Multiple paper assignments (practice at writing) but assignments are not clearly cumulative
Evidence of high-impact student engagement
Use incentive to reinforce formation of study groups. Provide guidelines for team skills or use formal exercises, activities or assignments to develop team skills (e.g. create a set of team roles and rules)
Assign group projects that are graded based on final product and peer evaluation (include rubric)
Encourage students to attend or become involved in cultural performances (Mechanism in course for earning extra credit for this or making this a graded/required component of the course)
Incorporate multiple teaching techniques with lecture (games, debates, skits, films) (These are described on the syllabus)
Multiple papers that build to completion of a larger project
Paper assignment includes a formal peer review activity before students submit the final draft of the paper for evaluation

(*Continued*)

High-impact pedagogical practices (2013 rubric)
Graded participation in class discussions (significant)
Flipped class preparation: Connect what students read, or prepared in advance, to course content (evaluated prior work to ensure it is completed)
Work with other students on projects **during class**
Work with classmate **outside of class** on assignments
Make a class presentation
Prepare two or more drafts of a paper or assignment
Serious conversations with 'different' others
Apply learning to real-world problems or experiences
Integrate ideas and reflect on how and what students are learning
Participate in campus event, speaker or activity **related to course**
Connect with a learning support service or resource (required)
Participate in a community-based project as part of the course
Small-scale experience or introduction to a high-impact practice (undergraduate research, service learning, study abroad, internship)

Appendix 2: Rubrics – Student Reflection :

Appendix B. Rubric—Student Reflections: TRAIL WRI 10

*If students do not meet the marginal level, please score as 0.

Student ID: Evaluator Initials:

Concept	Guiding Question	4 Advanced	3 Developing	2 Emerging	1 Marginal	Score
Academic Research Changes	To what extent has a student incorporated new practices into the academic research process?	Clearly outlines a **minimum of two** new or increasingly sophisticated research practices. Demonstrates **maturity** in the research process.	Clearly outlines a **minimum of two** new or increasingly sophisticated research practices. Demonstrates **strong progress** in the research process.	Outlines a **minimum of one** new or increasingly sophisticated research practice. Demonstrates **some progress** in the research process.	**May or may not outline a minimum** of one new or increasingly sophisticated research practice. Demonstrates **minimal progress** in the research process.	
Source Selection	Is the student using good judgment to select appropriate sources?	Provides a thoughtful rationale for determining the selection of sources. Refers to a minimum of three appropriate criterion in source selection considerations.	Provides a thoughtful rationale for determining the selection of sources. Refers to a minimum of two appropriate criterion in source selection considerations.	Provides an adequate rationale for determining the selection of sources. Refers to a minimum of one appropriate criterion in source selection considerations.	Provides a limited, incomplete, or superficial rationale for determining the selection of sources. May or may not refer to using appropriate criteria in source selection considerations.	
Challenges	Is the student overcoming research challenges with useful strategies?	Clearly identifies a **minimum of two** research challenges and provides **highly useful** strategies for overcoming them.	Clearly identifies a **minimum of two** research challenges and provides **some useful** strategies for overcoming them.	Identifies a **minimum of one** research challenge and provides **at least one** useful strategy for overcoming it.	**Identifies one or more** challenges but lacks useful strategies for overcoming challenges.	

Concept	Guiding Question	4 Advanced	3 Developing	2 Emerging	1 Marginal	Score
Attitude	Does the student convey the attitudes required of a researcher?	Tone and text **clearly convey** a positive attitude about the research process. Changes in research practices clearly indicate growth.	Tone and text **usually convey** a positive attitude about the research process. Changes in research practices clearly indicate growth.	Tone and text convey, at minimum, **some** positive attitudes about the research process. Changes in research practices indicate **some** growth.	Tone and text convey **some or limited** positive attitudes about the research process. Changes in research practices indicate **limited** growth.	
Transferability	Is the student applying research to other academic research needs?	Demonstrates a **strong understanding** of the applicability of the research process to other academic needs. Clearly identifies and illustrates with a **minimum of two** specific examples.	Demonstrates a **solid understanding** of the applicability of the research process to other academic needs. Clearly identifies and illustrates with a **minimum of one** specific example.	Demonstrates **some understanding** of the applicability of the research process to other academic needs. **May or may not illustrate** with one or more examples.	Makes a **limited connection** between the applicability of the research process to meeting other academic needs. **May or may not illustrate** with one or more relevant examples.	
Think Like a Researcher	Does the student understand the thinking required of a researcher?	Illustrates a **strong understanding** of the researcher mind-set. Refers to a **minimum of three** higher-level thinking characteristics required of researchers.	Illustrates a **solid understanding** of the researcher mind-set. Refers to a **minimum of two** higher-level thinking characteristics required of researchers.	Illustrates **some understanding** of the researcher mind-set. Refers to a **minimum of one** higher-level thinking characteristic required of researchers.	Illustrates a **limited understanding** of the researcher mind-set. May tangentially refer to higher-level thinking characteristics required of researchers.	
Comments/Observations/Student Quotes:					Total:	

Appendix C. Rubric—Evaluating Final WRI 10 Student Papers

*If students do not meet the marginal level, please score as 0.

Student Code:		Evaluator Initials				
Concept	**Guiding Question(s)**	**4 Advanced**	**3 Developing**	**2 Emerging**	**1 Marginal**	**Score**
Source Suitability	To what extent have students use suitable sources (credible, relevant) in their papers for evidence?	**All** sources are suitable.	**Most** sources are suitable.	**Some** sources are suitable.	**Few sources** are suitable.	
Argument & Evidence	Are students presenting multiple viewpoints? Do they support their arguments and counter-arguments with evidence?	**Multiple viewpoints** are presented. Arguments and counter-arguments are **strongly supported** with evidence.	**Multiple viewpoints** are presented. Arguments and counter-arguments are **adequately supported** with evidence.	**Multiple viewpoints** are presented. Arguments and counter-arguments are **minimally supported** with evidence.	A **single viewpoint** is presented and/or arguments **generally lack evidence**.	
Style	Do students cite sources accurately? Do they successfully produce proper in-text citations and bibliographies?	All in-text citations and bibliography references are consistently formatted in a standard citation style with **minor or no errors**. Citations include information needed for readers to locate the resource.	In-text citations and bibliography references are consistently formatted in a standard citation style with **few errors.** Citations **include most, if not all,** information needed for readers to locate the resources.	In-text citations and bibliography references are formatted in a standard citation style with **some errors**. Citations may be **missing** information needed for readers to locate the resources.	In-text citations and bibliography references are **often inconsistently formatted,** incomplete, and/or missing. Citations are **missing some information** needed for readers to locate the resources.	

Concept	Guiding Question(s)	4 Advanced	3 Developing	2 Emerging	1 Marginal	Score
Integration	Do students successfully incorporate sources in their papers? As needed, do they use introductory phrases and transitions in order to smoothly integrate text?	Sources receive attribution. Content is **expertly** incorporated into the text.	Sources receive attribution. Content is **satisfactorily** incorporated into the text.	Sources receive attribution. **Some** content is **satisfactorily** incorporated into the text.	Sources **may not** always receive attribution. **Some or little** content is **satisfactorily** incorporated into the text.	
Comments/Observations:						Total:
Source Selection Observation: (not formally part of the rubric)		□ **All or most** sources are selected from library collections or databases rather than the free web.		□ **Many** sources are selected from library collections or databases rather than the free web.	□ **Few** sources are selected from library collections or databases.	