

Analysing Informed Learning at Maastricht University

Stefan Jongen¹⁻², Jaro Pichel¹⁻², Frederike Vernimmen-de Jong¹ and Harm Hospers²

¹ University Library, Maastricht University, Maastricht, The Netherlands

² EDLAB Institute for Education Innovation, University Maastricht, Maastricht, The Netherlands

stefan.jongen@maastrichtuniversity.nl

Abstract. 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 paper is to answer the question how we can analyse informed learning at Maastricht University (UM) from a student and a teacher perspective. The present paper reviews several studies and these will provide input for an overall university-wide project (Title: Information-Wise) about integrating information literacy as part of problem-based learning at UM.

In conclusion, these are the five most important recommendations for 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 the perception of these issues in a teaching staff population 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 extent 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 [1], including level 4 (Results). This level 4 of measurement considers the big picture and long-term effects of instructions and should be taken into account if UM wants to have an impact of student learning beyond graduation regarding information literacy skills.

Information-Wise is a university-wide project aiming to identify and develop information literacy skills, which enable students to actively participate in the changing information environment. By collecting these data, we intend to increase the awareness regarding information literacy as part of the learning process for both students and teachers. In addition, these data will provide input for developing and tailoring generic and discipline-specific information literacy education at UM. During the conference on Learning Information Literacy across the Globe the first preliminary results of the overall project will be presented.

Keywords: Informed Learning, Information Literacy, Analysing Learning

1 Introduction

Learning is the process of acquiring new, or modifying existing, knowledge, behaviours, skills, values or preferences [2]. Learning how 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 [3]. 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 [4] 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 [4]. However, the problem is the limited information regarding the way students approach their learning and to what extent 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 [5].

1.1 Learning analytics as Part of Problem Based Learning 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 [6]. 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” [6]. 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 [6]. Generally, SRL consists of three main components: metacognition, motivation, and behaviour / cognition [7]. The last component refers to learning strategies that assist the learner in the effective processing,

use, and manipulation of information [8]. Nowadays, an important aspect of learning is dependent on effective information processing and the ability to cope with an increased volume of information [9].

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 [10]. “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 UL envisages an emphasis on self-directed learning and constructive alignment in faculty education programmes and integration of digital skills in information literacy training” [10]. 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.

1.2 Information Literacy

Both the UM and the UL put emphasis on analysing learning and important 21st-century skill development. In order to push these developments 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 [11]. 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. These standards illustrate the relationship between information literacy and self-directed learning.

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

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 [12].

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 [13]. 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 emphasize 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. Moreover, 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 [14].

1.3 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 [15]. Information literacy can be categorized in a functional, situated, or critical approach [16]. 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 [17].

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 [15]. 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 [15]. 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 [18]. 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 [19].

1.4 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, affective, and psychosocial behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment [20]. Learning styles define learning strategies to a certain extent. The effective use of different learning strategies is an important part of self-regulated learning [8]. Nowadays, an important aspect of learning is dependent on effective information processing and the ability to cope with an increased volume of information [9]. However, we have limited insights whether students use and switch between various learning strategies in effectively dealing with information.

1.5 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 little 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 paper The aim of the present paper 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.

2 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 [13]. 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?”

3 Analysing Informed Learning at Skill Course Level

Assessment of information literacy instruction is essential to demonstrate the efficacy of the services to university stakeholders [21]. The ACRL framework [13] 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 [12]. 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 [21] 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 be 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 [22]. See Table 1 for an overview of multiple assessment methods. Erlinger [22] employed two frameworks for the assessment types: formative (assessment during instruction) versus summative (i.e. assessment after learning is complete) and Kirkpatrick's four levels of assessment [1]. 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?

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 behaviour; 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 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; familiar	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

	ity and comfort on the part of administrators and stakeholders; high reliability.	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 behaviour 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 campus-wide 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. *Adapted from [22].*

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 [23]. 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). 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 [23].

Course Syllabi Analysis Another 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 [24]. 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 (SLOs) and assignments that aligned with information literacy standards (articulated by the Association of College and Research Libraries [12]). 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.

4 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 [7]. The last component refers to learning strategies that assist the learner in the effective processing, use, and manipulation of information [8]. Teachers can instruct the use of learning strategies by implicit and explicit instructions [25, 26]. 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 [26, 27].

Analysing information use in learning styles A definition of *learning styles* is 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 [20]. No consensus about an accepted method to assess individual learning styles currently exists, but several potential scales and classification are in use [28]. In their review of 2009, the authors outline four learning style measurements [28]. 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 [29]. 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 [30].

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) [31].

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 [32].

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 [34]. 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 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).

Table 2. Learning Techniques (adapted from [34])

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

The authors qualified practice testing, distributed practice, rereading, elaborative interrogation, and self-explanation as positive indicators of dealing with materials. Summarization was qualified 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.

5 Discussion

The aim of the present paper was 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 [15, 17]. The quality of teaching information literacy and the importance of the information literacy skills 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 [17]. Constructive alignment is a holistic curriculum design approach requiring optimal coherence between the three elements intended learning outcomes (ILOs), assessment methods, and teaching and learning activities (TLAs) [35].

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 and GPAs as quantitative data, and questionnaires for faculty members as qualitative data representing both direct and indirect evidence of student learning outcomes [23].

Moreover, qualitative data can be obtained from program directors and faculty teachers. At the faculty level, the ACRL framework [13] 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. Moreover, 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 [24]. 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.

At a skills course level, it is 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 [21]. 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 [22].

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 assessments 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) [1]. 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 (i.e. beyond graduation) regarding information literacy education, level 4 assessment should be taken into account.

An important aspect of teacher instructions is to be aware of differences 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 [30], the Learning Style Questionnaire [31], the Canfield Learning Style Inventory [32], and the Index of Learning Survey [33]. 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 [8]. Generally, teachers rarely integrate explicit instructions regarding SRL in their classroom because of difficulties with implementing theory into practice [26, 27]. It is of utmost importance that teachers do learn how to explicitly instruct all components of SRL [8], 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, re-reading, elaborative interrogation, and self-explanation [34]. 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 [34]. 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 [36]. 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 [37]. 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 [17]. 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.

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 the perception of teachers (faculty and library) about the use of 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 extent 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.

During the conference on Learning Information Literacy across the Globe the first preliminary results of the overall project (Information-Wise project) will be presented.

References

1. Kirkpatrick, D.L.: *Implementing the Four Levels: A Practical Guide for Effective Evaluation of Training Programs: Easyread Super Large 24pt Edition*. ReadHowYouWant. com (2009).
2. Holt, N., Bremner, A., Sutherland, E., Vlieg, M., Passer, M.W., Smith, R.E.: *Psychology: the science of mind and behaviour*. LondonMcGraw-Hill Education9780077169848 (2015).
3. Merrill, M.D., Drake, L., Lacy, M.J., Pratt, J., ID₂ Research Group: Reclaiming instructional design. *Educational Technology* 5-7 (1996).
4. Laurillard, D.: *Rethinking University Teaching : A Conversational Framework for the Effective Use of Learning Technologies*. Routledge, Hoboken (2013).
5. Learning Analytics, <http://www.learninganalytics.net/uncategorized/learning-and-academic-analytics/>, last accessed 2018/10/02.
6. Maastricht University, <https://www.maastrichtuniversity.nl/about-um/organisation/mission-strategy>, last accessed 2018/12/11.
7. Vermunt, J.D., Verloop, N.: Congruence and friction between learning and teaching. *Learning and instruction* 9, 257-280 (1999).
8. De Smul, M., Heirweg, S., Van Keer, H., Devos, G., Vandevelde, S.: How competent do teachers feel instructing self-regulated learning strategies? Development and validation of the teacher self-efficacy scale to implement self-regulated learning. *Teaching and Teacher Education* 71, 214-225 (2018).
9. Cornford, I.R.: Learning-to-learn strategies as a basis for effective lifelong learning. *International journal of lifelong education* 21, 357-368 (2002).
10. Maastricht University Library, https://www.maastrichtuniversity.nl/sites/default/files/downloadables/maastricht_university_library_-_strategic_agenda_2017-2021-en.pdf, last accessed 2018/12/11
11. Lodge, J.M.: Do the learning sciences have a place in higher education research? *Higher Education Research & Development* 35, 634-637 (2016)
12. American Library Association, <https://alair.ala.org/handle/11213/7668>, last accessed 2018/11/24.
13. Association of College Research Libraries: *Framework for information literacy for higher education*. Association of College and Research Libraries, a division of the American Library Association (2015).
14. Pichel, J., Jongen, S., Hospers, H.: The changing role of information literacy skills in higher education. In: Maastricht University (ed.), (2018).
15. Bruce, C., Hughes, H.: Informed learning: A pedagogical construct attending simultaneously to information use and learning. *Library & Information Science Research* 32, A2-A8 (2010).
16. Lupton, M., Bruce, C.: Windows on information literacy worlds: Generic, situated and transformative perspectives. *Practising information literacy: Bringing theories of learning, practice and information literacy together* 4-27 (2010).
17. Maybee, C.: *IMPACT Learning: Librarians at the Forefront of Change in Higher Education*. Chandos Publishing (2018).
18. Walker, S.E.: Active learning strategies to promote critical thinking. *Journal of athletic training* 38, 263 (2003).
19. Schmidt, H.G.: Problem-based learning: rationale and description. *Medical education* 17, 11-16 (1983).
20. Curry, L.: Learning preferences and continuing medical education. *Canadian Medical Association Journal* 124, 535 (1981).
21. Anderson, M.J.: Rethinking assessment: Information literacy instruction and the ACRL Framework. *School of Information Student Research Journal* 5, 3 (2015).
22. Erlinger, A.: Outcomes assessment in undergraduate information literacy instruction: A systematic review. *College & Research Libraries* 79, 442 (2018).

23. Squibb, S.D., Mikkelsen, S.: Assessing the Value of Course-Embedded Information Literacy on Student Learning and Achievement. *College & Research Libraries* 77, 164-183 (2016).
24. Stanny, C., Gonzalez, M., McGowan, B.: Assessing the Culture of Teaching and Learning through a Syllabus Review. *Assessment & Evaluation in Higher Education* 40, 898-913 (2015).
25. Kistner, S., Rakoczy, K., Otto, B., Klieme, E., Büttner, G.: Teaching learning strategies: The role of instructional context and teacher beliefs. *Journal for educational research online* 7, 176-197 (2015).
26. Kistner, S., Rakoczy, K., Otto, B., Dignath-van Ewijk, C., Büttner, G., Klieme, E.: Promotion of self-regulated learning in classrooms: Investigating frequency, quality, and consequences for student performance. *Metacognition and learning* 5, 157-171 (2010).
27. Spruce, R., Bol, L.: Teacher beliefs, knowledge, and practice of self-regulated learning. *Metacognition and Learning* 10, 245-277 (2015).
28. Romanelli, F., Bird, E., Ryan, M.: Learning styles: a review of theory, application, and best practices. *American journal of pharmaceutical education* 73, 9 (2009).
29. Kolb, D.A.: *Experiential learning: Experience as the source of learning and development*. Prentice-Hall, Englewood Cliffs, NJ (1984).
30. Kolb, D.A.: *Learning-style inventory: Self-scoring inventory and interpretation booklet: Revised scoring*. TRG, Hay/McBer (1993).
31. Honey, P., Mumford, A.: *The learning styles helper's guide*. Peter Honey Publications Maidenhead, Maidenhead (2000).
32. Canfield, A.A.: *Learning styles inventory (LSI)*. Western Psychological Services, Los Angeles, Cali (1992).
33. Felder, R.M., Silverman, L.K.: Learning and teaching styles in engineering education. *Engineering education* 78, 674-681 (1988).
34. Dunlosky, J., Rawson, K.A., Marsh, E.J., Nathan, M.J., Willingham, D.T.: Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest* 14, 4-58 (2013).
35. Biggs, J.B.: *Teaching for quality learning at university: What the student does*. McGraw-hill education (UK) (2011).
36. Kirschner, P.A.: Stop propagating the learning styles myth. *Computers & Education* 106, 166-171 (2017).
37. Coffield, F., Moseley, D., Hall, E., Ecclestone, K.: *Learning styles and pedagogy in post-16 learning: A systematic and critical review (application/pdf Object)*. (2004).