

## Chapter 2

# Teaching and Learning Analytics to Support Teacher Inquiry: A Systematic Literature Review

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**Abstract** *Teacher inquiry* is identified as a key global need for driving the continuous improvement of the teaching and learning conditions for learners. However, specific barriers (mainly related to teachers' data literacy competences), can defer teachers from engaging with inquiry to improve their teaching practice. To alleviate these barriers and support teacher inquiry, the concept of *Teaching and Learning Analytics (TLA)* has been proposed, as a complementing synergy between Teaching Analytics and Learning Analytics. Teaching and Learning Analytics aims to provide a framework in which the insights generated by Learning Analytics methods and tools can become meaningfully translated for driving teachers' inquiry to improve their teaching practice, captured through Teaching Analytics methods and tools. In this context, TLA have been identified as a research challenge with significant practical impact potential. This chapter contributes the first systematic literature review in the emerging research field of Teaching and Learning Analytics. The insights gained from the systematic literature review aim to (a) transparently outline the existing state-of-the-art following a structured analysis methodology, as well as (b) elicit insights and shortcomings which could inform future work in the Teaching and Learning Analytics research field.

**Keywords** Teaching analytics · Teacher inquiry · Learning analytics · Educational design · Teacher reflection

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## Abbreviations

ED	Educational design
RQ	Research question
SLR	Systematic literature review
SNA	Social network analysis
TLA	Teaching and learning analytics

## 2.1 Introduction

Data-driven teacher appraisal is among the key priorities of educational policies worldwide for continuously monitoring and improving the teaching and learning conditions offered to learners (OECD 2013). Data-driven teacher appraisal can be related either to (OECD 2009):

- *Meeting external accountability mandates*, which take a summative standpoint towards assessment of teachers' educational design and delivery practice or
- *Developing a continuous cycle of self-improvement*, which is guided by the teachers themselves and takes a formative standpoint towards improvement.

However, since the latter can also be considered as a pre-requisite for the former, explicit focus is being placed for supporting teachers to engage in self-evaluation and improvement of their practice (namely educational design and delivery), in a process commonly termed as *teacher inquiry* (Check and Schutt 2012).

Teacher inquiry refers to a continuous process of investigation, reflection and improvement of teaching practice, based on the collection, analysis and interpretation of diverse educational data (Avramides et al. 2015). However, despite the emerging global need for teachers to engage in inquiry, specific barriers can hinder its wide adoption. Examples of such barriers include teachers' low *data literacy* competences for collecting, analyzing and interpreting educational data (Marsh and Farrell 2014), the need for timely data collection and analysis (Kaufman et al. 2014) as well as the quality of educational data that can be manually collected (Mandinach 2012). To address these barriers, specific data Analytics strands have emerged, as follows:

- *Teaching Analytics*, which refers to the methods and digital tools to help teachers analyze and improve the educational designs prior to the delivery. Furthermore, more recent developments on Teaching Analytics also support analysis of how the teacher delivers the educational designs (e.g., Gauthier 2013; Prieto et al. 2016).<sup>1</sup>

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<sup>1</sup>In this book chapter, we will consider this extended strand of Teaching Analytics research as part of the *proposed concept of Teaching and Learning Analytics (TLA)* and not as part of the Teaching Analytics strand.

- *Learning Analytics*, which refer to the methods and digital tools that allow the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs (SOLAR 2011).

However, each Analytics strand focuses on supporting specific inquiry tasks, namely Teaching Analytics mainly focus on capturing and analyzing the teacher actions during the educational design and delivery process, while Learning Analytics mainly focus on capturing and analyzing the learner actions, despite the explicit mention of “[educational] **context**” in their definition. Therefore, each digital Analytics strand can offer fragmented support to teachers towards reflecting on and improving their educational design and delivery. More specifically, Teaching Analytics do not account for the learners’ actions and, therefore may have limited value for evaluating the impact of educational designs. On the other hand, Learning Analytics have not yet fully accounted for the aspect of context (namely educational design and delivery), which is a significant factor that can affect learners’ performance and progress (e.g., Dyckhoff 2011; Toetenel and Rienties 2016). The latter limitation is also noticeable in a number of recent analyses of the Learning Analytics research field (e.g., Papamitsiou and Economides 2014; Sin and Muthu 2015; Nunn et al. 2016).

As a response to this need, a new Analytics strand has been proposed, which can be termed *Teaching and Learning Analytics (TLA)*. TLA is presented as a synergy between Teaching Analytics and Learning Analytics in order to holistically support the process of teacher inquiry. More specifically, TLA argues for the need for methods and tools that will allow teachers to analyze their educational design and delivery process and also utilize learners’ educational data for evidence-based evaluation, reflection on and improvement of this process (McKenney and Mor 2015). This synergy has been considered as one of the key research challenges in the field of Technology-enhanced Education (Lockyer et al. 2013; Wasson et al. 2016).

In this context, this book chapter reports on the first systematic literature review (SLR) in the emerging research field of TLA. The contribution of this book chapter is that it analyzes the current state-of-the-art in the TLA research, using the concept of teacher inquiry as a backbone analysis framework, with the aim of providing transparent overview of overarching insights and shortcomings.

The remainder of the book chapter is structured as follows: Sect. 2.2 presents the background of this work related to the concept of teacher inquiry and Teaching and Learning Analytics. Section 2.3 presents the methodology followed in the systematic literature review process. Section 2.4 presents the results of the systematic literature review. Finally, Sect. 2.5 discusses the main findings and conclusions. The Appendix section contains the full analysis of the state-of-the-art research TLA works, following the analysis framework described in Sect. 2.3.

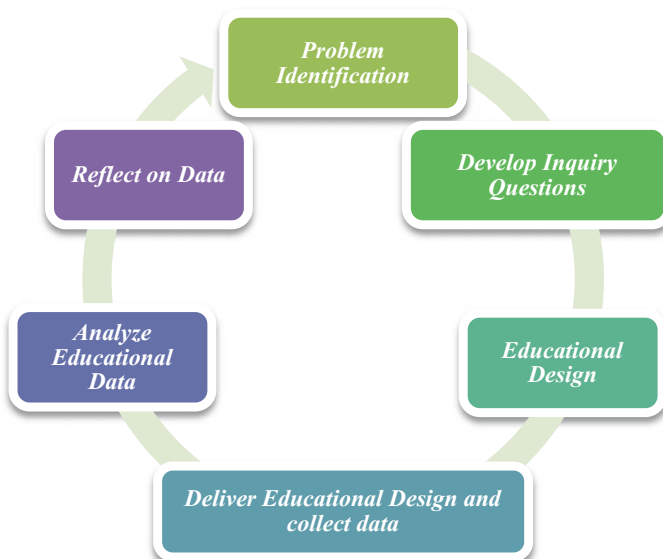
## 2.2 Background

This section will initially present the foundational concepts, namely *teacher inquiry* and *Teaching and Learning Analytics* in corresponding sections. Furthermore, it will outline the manner in which the two concepts are connected and how TLA can provide more holistic support to teachers for engaging in the full spectrum of tasks associated with teacher inquiry.

### 2.2.1 Teacher Inquiry

Teacher inquiry is defined as a sequence of actions in which “*teachers identify questions for investigation in their practice and then design a process for collecting evidence about student learning that informs their subsequent educational designs*” (Avramides et al. 2015). Essentially, teacher inquiry is a form of action research, in which teachers define specific questions regarding their educational design and delivery and collect evidence to answer these questions (Altrichter et al. 2008). Therefore, this process can guide reflection and improvement in a systematic and evidence-based manner (Dana and Yendol-Hoppey 2014).

Teacher inquiry generically follows a cycle of steps (Timperley et al. 2010; Hansen and Wasson 2016), which is outlined as follows (also depicted in Fig. 2.1):



**Fig. 2.1** Overview of the teacher inquiry cycle

- *Step 1: Problem Identification.* During this step, the teacher identifies a specific aspect of their educational design and/or delivery that they wish to investigate/evaluate in order to improve it.
- *Step 2: Develop Inquiry Questions.* During this step, the teacher defines the specific questions that they will investigate, related to evaluating or investigating aspects of their educational design and/or delivery. Furthermore, the teacher defines which *educational data* they will need to collect during delivery to answer the specific question they defined, as well as the method for collecting these data.
- *Step 3: Educational Design.* During this step, the teacher formulates the educational design which they will deliver in order to implement their inquiry.
- *Step 4: Deliver Educational Design and collect data.* During this step, the teacher delivers the educational design to the learners and collects the educational data using the collection method.
- *Step 5: Analyze educational data.* After the teacher has collected the educational data, they analyse them in order to elicit insights to answer the inquiry question they have defined.
- *Step 6: Reflect on data.* Finally, the analysed data are used by the teacher in order to answer the defined inquiry question and (if needed) revise the practice in which they conduct their educational design and/or delivery.

As aforementioned, teacher inquiry is gaining momentum globally as teachers are continuously expected to improve the teaching and learning conditions for their learners on an evidence-based manner (OECD 2013). However, despite this emerging push, specific barriers exist that hinder teachers perform each step of the inquiry cycle, including teachers' low *data literacy* competences to collect, analyze and interpret educational data (Marsh and Farrell 2014), untimely collection and analysis of educational data (Kaufman et al. 2014) and low quality of educational data that can be manually collected by the teacher (Mandinach 2012). To address these issues and facilitate teachers in performing the tasks of the inquiry cycle, a research synergy to exploit the potential of Teaching Analytics and Learning Analytics has been recently proposed, namely TLA. The following section describes the concept of TLA and how it can support the process of teacher inquiry.

### 2.2.2 Teaching and Learning Analytics

The emerging research strand of TLA refers to the methods and tools for supporting teachers engage in inquiry for reflecting on and improving their educational design and delivery. To do that, TLA aims to combine the individual capacity of Teaching Analytics and Learning Analytics in order to exploit:

- The potential of *Teaching Analytics* to analyze the educational designs in the constituent elements (e.g., learning and assessment activities and educational resources/tools) and the interrelations between these elements.
- The potential of *Learning Analytics* to measure, collect, analyse and report on learners' educational data and the learning context that they are generated, aiming to improve the learning conditions for individual learners or groups of learners (Papamitsiou and Economides 2014).

Essentially, TLA introduces a framework that aims to combine the focal points of the existing Analytics strands and re-purpose them towards addressing a new challenge, which is currently under-supported by each individual strand in isolation. More specifically, TLA argues that insights generated by Learning Analytics methods and tools can be mapped to the analyzed (through Teaching Analytics tools) elements of teaching practice that generated them, and therefore support teachers to reflect on and improve their educational design and delivery based on evidence (Greller et al. 2014; Greller and Drachsler 2012; Emin-Martinez et al. 2014; Bakharia et al. 2016). In this regard, TLA is appropriate to support the concept of teacher inquiry (Mor et al. 2015), as defined in the previous section, and it can be directly linked to all teacher inquiry cycle, as indicated in Table 2.1.

Therefore, in this book chapter, TLA will be defined as a framework to guide the process of teachers' reflection on their educational design and delivery, based on evidence from educational data related to both their learners, as well as their own.

As aforementioned, the research field of TLA is still relatively new but highly emerging and important (Wasson et al. 2016). Based on this fact, it is reasonable to argue for the need to have a systematic and critical overview of the current research state-of-the-art. This overview will provide insights on how the existing works have been aligned to the overarching challenge that TLA is aimed to address, namely

**Table 2.1** Mapping between TLA and the steps of teacher inquiry cycle

Teacher inquiry cycle steps	How TLA can contribute
1. Problem identification	Teaching analytics can be used to capture and analyze the educational design and facilitate the teacher to: <ul style="list-style-type: none"> <li>• pinpoint the specific elements of their educational design that relate to the problem they have identified and</li> <li>• elaborate on their inquiry question by defining explicitly the educational design elements they will monitor and investigate in their inquiry</li> </ul>
2. Develop inquiry questions	
3. Educational design	
4. Deliver educational design and collect data	Learning analytics can be used to collect the learner/teacher educational data that have been defined to answer their inquiry question.
5. Analyze data	Learning analytics can be used to analyse and report on the collected data and facilitate sense-making
6. Reflect on data	The combined use of TLA can be used to answer the inquiry questions and support reflection on educational design and delivery

support the process of teacher inquiry. Furthermore, these insights could also outline shortcomings that future TLA research could aim to address.

In this context, the contribution of this book chapter is to perform a systematic literature review in the research field of TLA and provide the aforementioned insights following a systematic approach. Using the teacher inquiry cycle as a backbone framework, the SLR was structured and implemented based on a specific step-by-step methodology, which is described in detail in the following section.

## 2.3 Systematic Literature Review Methodology

The systematic literature review followed the widely accepted methodology of Kitchenham and Charters (2007). More specifically, the methodology included the definition of (a) the analysis framework of existing research works (depicting the research questions addressed), (b) the literature inclusion and exclusion criteria and (c) the literature search strategy adopted (Brereton et al. 2007). Each of these methodology steps are described in the following sections.

### 2.3.1 *Research Questions: Research Work Analysis Framework*

In order to provide a structured method to analyze the existing research works in Teaching and Learning Analytics, a set of research questions were defined. These research questions aimed to collect insights on how the current state-of-the-art in TLA supports the steps of the inquiry cycle, as they were outlined in Table 2.1.

The research questions (analysis framework) were defined as follows:

- *RQ1. What Teaching Analytics tasks were employed?* This Research Question was related to the steps of the inquiry cycle related to “Problem Identification”, “Develop Inquiry Questions” and “Educational Design”. It aimed to elicit the Teaching Analytics tasks that each research work adopted in terms of analyzing the educational design and, thus, supporting the teacher to clearly define inquiry questions based on the problems they had identified.
- *RQ2. Which educational data types were collected regarding the learner?* This Research Question was related to the step of the inquiry cycle “Develop Inquiry Questions” and aimed to identify the educational data types that each research work collected, related to learners.
- *RQ3. Which educational data types were collected regarding the teacher?* This Research Question was related to the step of the inquiry cycle “Develop Inquiry Questions” and aimed to identify the educational data types that each research work collected, related to teachers.

- *RQ4. What data analysis method was used to process the collected teacher/learner data?* This Research Question was related to the steps of the inquiry cycle “Deliver Educational Design and collect data” and “Analyze educational data”. It aimed to identify the (Learning Analytics) methods that each research work exploited towards processing the learners’ and teachers’ educational data.
- *RQ5. Which was the focus of reflection?* This Research Questions was related to the step of the inquiry cycle “Reflect on Data”. It aimed to identify which aspect of teachers’ practice the TLA work provided reflective insights for.
- *RQ6. Were teachers provided with recommendations for supporting reflection?* This Research Question was related to the step of the inquiry cycle “Reflect on Data”. It aimed to elicit whether the research work provided recommendations to support teachers’ reflection and sense-making, or whether the teacher had to engage in ad hoc reflective insights based on their own reasoning.

### 2.3.2 Inclusion and Exclusion Criteria

In order to ensure that the identified research works were relevant to answer the Research Questions of this SLR, a set of inclusion and exclusion criteria was defined. The adopted inclusion and exclusion criteria are as follows:

- **Inclusion Criterion:**
  - Publications should describe original research work related to the use of TLA methods/tools for supporting the teacher to reflect on their teaching design and delivery.
  - No restriction was imposed on the date of publication of the publications.
- **Exclusion Criteria:**
  - Publications should not focus solely on the use of Teaching Analytics methods and tools that do not take into account the delivery of the educational design.
  - Publications should not focus solely on the use of Learning Analytics methods and tools to exclusively facilitate the teacher support individual learners’ progress (but not reflection on their educational design and delivery).
  - Publications should not be included in the conference proceedings as posters (in case of conference publications).
  - Publications should be written in English.
  - Abstract-only publications were not considered.
  - Updated versions of the same publications were only considered once.

### 2.3.3 Literature Search Strategy

The literature search strategy was devised in order to identify and collect research works and use them to answer the proposed research questions. Following recommended practice in systematic literature reviews (Brereton et al. 2007), the search strategy adopted the following protocol in terms of keyword. The *keywords* for guiding the search were selected. In order to ensure that any relevant research papers would not be excluded at this point, general keywords were used, namely “*Teaching Analytics*”, “*Learning Analytics*”, “*Educational Analytics*”, “*Teacher Inquiry*”, “*Analytics*”. Additionally, the use of Boolean operators (OR, AND) among the general keywords was also performed in order to extend the search results. The keywords were appropriately selected in order to include the key concepts relevant to the focus of the SLR. By adopting general keywords, research works that were relevant to the SLR but did not explicitly use terms such as “teacher inquiry”, were also captured. The timeframe in which this literature search was conducted was May–June 2016.

Regarding the *digital databases* used in the search, these included prestigious scientific journals and international conference proceedings relevant to the field of Teaching Analytics and Learning Analytics, as follows:

- Journal of Learning Analytics [<http://learning-analytics.info/>].
- Computers & Education [<http://www.journals.elsevier.com/computers-and-education>].
- British Journal of Educational Technology [[http://onlinelibrary.wiley.com/journal/10.1111/\(ISSN\)1467-8535](http://onlinelibrary.wiley.com/journal/10.1111/(ISSN)1467-8535)].
- Journal of Educational Technology & Society [<http://www.ifets.info>].
- IEEE Transactions on Learning Technologies [<https://www.computer.org/web/tlt>].
- Computers in Human Behavior [<http://www.journals.elsevier.com/computers-in-human-behavior>].
- Proceedings of the Learning Analytics and Knowledge (LAK) Conference (2012–2016) [<https://solaresearch.org/events/lak/>].
- IEEE Conference on Advanced Learning Technologies (ICALT) (2012–2015) [<http://ieeexplore.ieee.org/>].
- Furthermore, relevant research works directly cited in the initially identified publications from the above databases were also considered.

The research works selection process was conducted in two steps, as follows:

- *Step 1.* All research works retrieved using the literature search strategy were assessed based on the inclusion and exclusion criteria (defined in Sect. 2.3.2). At this step, each research work was initially assessed in terms of the title and abstract in order to identify and reject papers that were not relevant to the aims and Research Questions of this SLR.

- *Step 2.* All research works that were initially approved during Step 1, were more deeply analyzed based on the full text in order to ensure that they were relevant to the Research Questions.

After the aforementioned process was finalized, a pool of 54 *research works* remained, which was used for addressing the defined Research Questions.

2.4 Systematic Literature Review Results

This section will present the results of the SLR for each of the Research Questions. The results for each of the RQ is outlined in a separate sub-section, presenting both a discussion of results as well as quantitative analyses of the collected data. Furthermore, a detailed table depicting the full quantitative results of the full SLR can be found in the Appendix section.

2.4.1 Results Related to the Teaching Analytics Tasks Employed (RQ1)

The RQ1 was aimed to elicit which Teaching Analytics tasks each research work adopted in order to support the first three steps of the inquiry cycle. The critical analysis of existing works highlighted a set of three overarching and recurring Teaching Analytics tasks, which are depicted in Table 2.2 and Fig. 2.2.

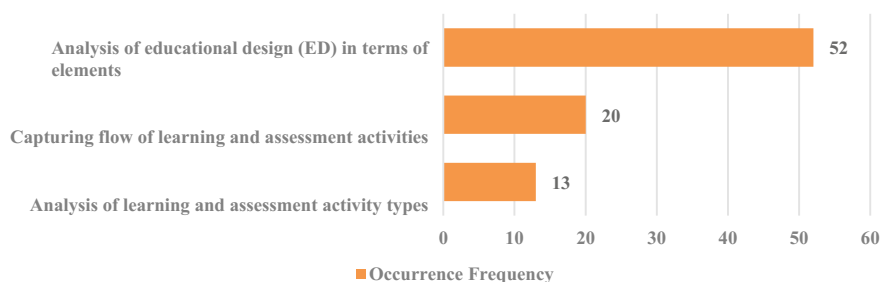
As Table 2.2 depicts, the analysis of research works led to the definition of the following Teaching Analytics tasks:

- *Analysis of ED in terms of elements* (N = 52, x = 96.3%). This Teaching Analytics task related to the basic analysis of the educational design in terms of its constituent elements. More specifically, this task aims to create a structured representation of the educational design, where each element (i.e., each learning activity, assessment activity and/or educational resource/tool) is explicitly defined. The *main aim* of this task is to support the teacher transparently

Table 2.2 Teaching analytics tasks

#	Overarching teaching analytics task	Occurrence frequency (N = 54)	Percentage (%)
1	Analysis of educational design (ED) in terms of elements	52	96.3
2	Capturing the flow of learning and assessment activities	20	37.0
3	Analysis of learning and assessment activity types	13	24.1

The teaching analytics tasks were not mutually exclusive in each research work



**Fig. 2.2** Overview of the teaching analytics tasks

‘decompose’ their educational design and, therefore, be able to define and investigate inquiry questions on each comprising element (e.g., Romero et al. 2008; Hung et al. 2012).

- *Capturing the flow of learning and assessment activities* (N = 20, x = 37.0%). This Teaching Analytics task extended the previous task, by not only capturing the learning and assessment activities of the educational design but also defining the specific flow in which these should be delivered. The *main aim* of this task is to enable the teacher to compare between their designed flow of activities and the flow that their learners follow during delivery (e.g., Camilleri et al. 2013).
- *Analysis of learning and assessment activity types* (N = 13, x = 24.1%). This Teaching Analytics task aimed to include another layer of detail when analyzing the educational design, by classifying the learning and assessment activities in specific types (which were defined based on the focus of each work). To give an example, Rienties et al. (2015) classified learning activities in seven types (*productive, assimilative, assessment, communication, finding and handling information, experiential, interactive*). The *main aim* of this task is to allow teachers to define and answer inquiry questions related to how different learning activity types can impact their learners’ performance (e.g., Gómez-Aguilar et al. 2015) or their own actions when delivering the educational design (e.g., Prieto et al. 2016).

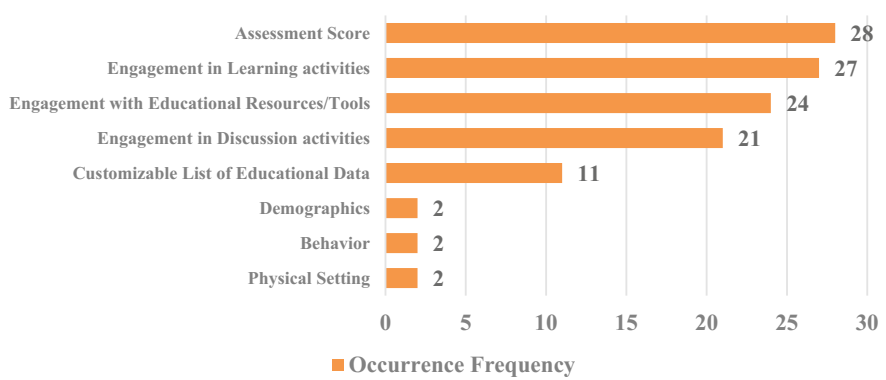
### 2.4.2 Results Related to the Educational Data Types Collected Regarding the Learner (RQ2)

The RQ2 was aimed to elicit the learner educational data types that TLA research adopt in order to support the second step of the inquiry cycle (“Develop Inquiry Questions”). Table 2.3 and Fig. 2.3 depict the resulting set of seven overarching learner educational data types that were elicited from the critical analysis of the TLA research works. It is mentioned that 52 (out of the overall 54) TLA research works utilized learners’ educational data.

**Table 2.3** Learner educational data types

#	Learner educational data type	Occurrence frequency (N = 52)	Percentage (%)
1	Assessment scores	28	53.8
2	Engagement in learning activities	27	51.9
3	Engagement with educational resources or tools	24	46.2
4	Engagement in discussion activities	21	40.4
5	Customizable list of educational data	11	21.2
6	Demographics	2	3.8
7	Behavior	2	3.8
8	Physical setting	2	3.8

The educational data types were not mutually exclusive in each research work



**Fig. 2.3** Overview of the learner educational data types

As Table 2.3 depicts, the analysis of research works highlighted the following learner educational data types:

- *Assessment scores* (N = 28,  $x = 53.8\%$ ). This educational data type refers to formative or summative assessment performance of the learners during the delivery of the educational design. The *main aim* of this educational data type is to offer a benchmark for evaluating the impact on the learners’ performance of specific educational design elements (e.g., specific learning activities) (Mirriahi and Dawson 2013; Hernández-García et al. 2015) or the teachers’ actions during the delivery of the educational design (e.g., Howlin and Lynch 2014).
- *Engagement in learning activities* (N = 27,  $x = 51.9\%$ ). This educational data type refers to the level in which learners engaged with the learning activities, in terms of either time spent on the activities (e.g., Fernández-Gallego et al. 2013)

or frequency of attempts of the activities (e.g., El-Bishouty et al. 2015). The *main aim* of this educational data type was to identify the learning activities that were attributed with low learner engagement and therefore, might need revising. Moreover, learning activities which highly engaged learners could also be highlighted, in order to provide the teacher with a ‘good-practice’ blueprint.

- *Engagement with educational resources or tools* (N = 24, x = 46.2%). This educational data type refers to the level in which learners engaged with the educational resources and tools, in terms of either time spent on the educational resources/tools (e.g., Rienties et al. 2015) or frequency of access/use (e.g., Mirriahi and Dawson 2013). The *main aim* of this educational data type was to help the teacher pinpoint specific educational resources/tools that were not engaging to the learners and, therefore, might need to be revised or replaced.
- *Engagement in Discussion activities* (N = 21, x = 40.4%). This educational data type refers to the level of engagement of learners in the learning activities that explicitly included discussions between the learners or between the learners and the teacher (e.g., through a forum). The *main aim* of this educational data type was to provide evidence on which of these discussion activities were engaging (or not) to the learners and, inform teachers to possibly revise them (e.g., Ali et al. 2012).
- *Customizable List of Educational Data* (N = 11, x = 21.2%). This educational data ‘type’ aims to depict research works that either did not provide an exhaustive list of the learner educational data they collected (e.g., Mazza and Milani 2005) or allowed the teacher to define a custom array of educational data to be considered (from the presented set of seven overarching learner educational data types) (e.g., Kladich et al. 2013).
- *Demographics* (N = 2, x = 3.8%). This educational data type mainly refers to learners’ past competences. The *main aim* of this educational data type was to allow teachers to reflect on their educational design/delivery (or specific elements), by also explicitly taking into account learners’ prior competences (e.g., Dunbar et al. 2014).
- *Behavior* (N = 2, x = 3.8%). This educational data type mainly refers to learners’ level of attendance during the delivery of the educational design. The *main aim* of this educational data type was to allow teachers to explicitly consider the level in which learners attended the delivery as an additional evaluation variable when they reflect on their educational design and delivery (e.g., Bos and Brand-Gruwei 2016).
- *Physical Setting* (N = 2, x = 3.8%). This educational data type was used in research works that aimed to study TLA in the context of informal settings. The *main aim* of this educational data type was to allow teachers to investigate whether their learners were following the designed flow of learning and assessment activities (in the physical space) and whether there were any deviations that could inform revisions in subsequent educational designs (e.g., Melero et al. 2015).

2.4.3 Results Related to the Educational Data Types Collected Regarding the Teacher (RQ3)

The RQ3 was aimed to elicit the teacher educational data types that TLA research adopt in order to support the second step of the inquiry cycle (“Develop Inquiry Questions”). As Table 2.4 and Fig. 2.4 depict, a set of three overarching teacher educational data types were elicited from a total of 15 research works that utilized such educational data.

As Table 2.4 depicts, the analysis of research works highlighted the following teacher educational data types:

- *Engagement in discussion activities* (N = 11, x = 73.3%). This educational data type refers to the frequency of teachers’ participation in learning activities focused on discussion (e.g., through a forum). The *main aim* of this educational data type is to support teachers to reflect on the way they supported learners during these activities, in terms of feedback and scaffolding (e.g., Dawson 2010). Furthermore, this educational data type could also relate to analyzing the content of the interventions made by the teacher, in order to help them assess the ‘quality’ of feedback and scaffolding provided (e.g., van Leeuwen et al. 2015).
- *Engagement in learning activities* (N = 6, x = 40.0%). This educational data type refers to the level in which teachers participated in the learning activities, in terms of providing feedback and support to the learners as well as orchestrating the delivery of the learning activities (Prieto et al. 2011; Martinez-Maldonado et al. 2016). The *main aim* of this educational data type was to provide evidence to teachers on (a) whether they provided the level of feedback and support they had initially planned for or (b) whether they orchestrated the delivery of the

Table 2.4 Teacher educational data types

#	Teacher educational data type	Occurrence frequency (N = 15)	Percentage (%)
1	Engagement in discussion activities	11	73.3
2	Engagement in learning activities	6	40.0
3	Location/physical data	1	6.7

The educational data types were not mutually exclusive in each research work

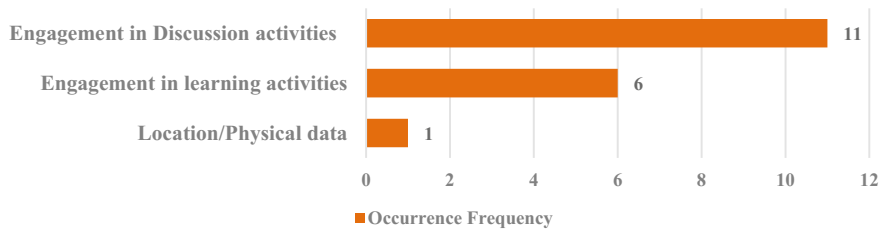


Fig. 2.4 Overview of the teacher educational data types

learning activities according to their initial design. In both cases, teachers gained access to evidence that could help them identify and improve potentials problematic aspects in their practice.

- *Location/Physical Data* (N = 1, x = 6.7%). This educational data type refers to teachers’ physical data (e.g., eye-tracking) and physical setting data (e.g., position and point-of-view). The *main aim* of this educational data is to collect highly granulated evidence on the specific physical actions teachers made during the delivery of their educational design, without the need for manual data collection and analysis (e.g., Prieto et al. 2016).

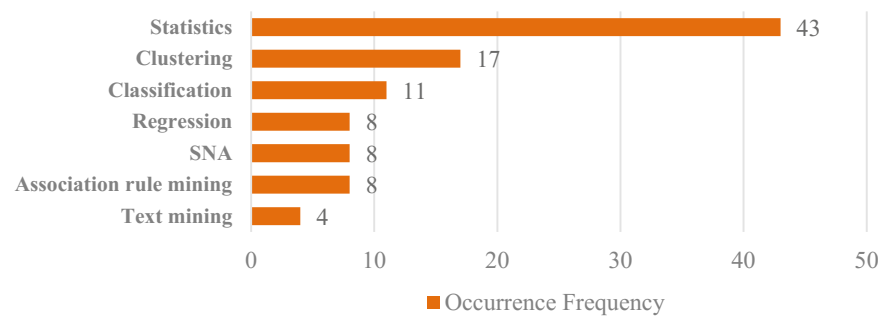
**2.4.4 Results Related to the Data Analysis Method Used to Process the Collected Teacher and Learner Educational Data (RQ4)**

The RQ4 was aimed to elicit the analysis methods that existing TLA research works employ in order to support the “Deliver Educational Design and collect data” and “Analyze educational data” steps of teacher inquiry. Table 2.5 and Fig. 2.5 present

**Table 2.5** Data analysis methods for learner educational data

#	Data analysis method	Occurrence frequency (N = 52)	Percentage (%)
1	Statistics	43	82.7
2	Clustering	17	32.7
3	Classification	11	21.2
4	Regression	8	15.4
5	Social network analysis (SNA)	8	15.4
6	Association rule mining	8	15.4
7	Text mining	4	7.7

The data analysis methods were not mutually exclusive in each research work

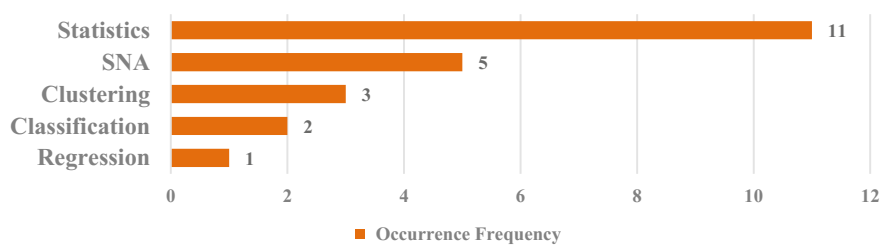


**Fig. 2.5** Overview of data analysis methods for learner educational data

**Table 2.6** Data analysis methods for teacher educational data

#	Data analysis method	Occurrence frequency (N = 15)	Percentage (%)
1	Statistics	11	73.3
2	SNA	5	33.3
3	Clustering	3	20.0
4	Classification	2	13.3
5	Regression	1	6.7

The data analysis methods were not mutually exclusive in each research work



**Fig. 2.6** Overview of data analysis methods for teacher educational data

the results of RQ4 regarding the data analysis methods used to process the collected (from Learning Analytics tools) learner educational data, whereas Table 2.6 and Fig. 2.6 present the results of RQ4 regarding the data analysis methods used to process teacher educational data.

As Table 2.5 depicts, a set of seven overarching data analysis methods were employed by the existing TLA research works. Furthermore, it is mentioned that all 52 research works that exploited learner educational data utilized at least one analysis method to process them.

Table 2.6 and Fig. 2.6 present the results of RQ4 regarding the data analysis methods used to process teachers’ educational data, which comprised a set of five such methods. As the Table 2.6 depicts, all research works that utilized teachers’ educational data (N = 15) also adopted a method (or more) to analyze them.

As both Tables 2.5 and 2.6 depict, the identified data analysis methods used in the existing TLA research works are consistent with the relevant framework proposed by Papamitsiou and Economides (2014). Therefore, these data indicate that TLA approaches have directly built on the existing Learning Analytics methods and tools, simply re-aligning the purpose for which they are exploited (namely, to support teacher inquiry).

2.4.5 Results Related to the Focus of Reflection (RQ5)

The RQ5 was aimed to elicit the aspects of teachers’ practice that TLA focused on, namely which was the *TLA task* that aimed to support the final step of the inquiry cycle (“Reflect on data”). Table 2.7 and Fig. 2.7 present the identified set of four overarching TLA tasks. It is mentioned that all 54 research works focused on achieving at least one TLA task.

- As Table 2.7 depicts, the elicited TLA tasks are as follows:
- *Evaluation of educational design elements based on educational data* (N = 41, x = 75.9%). This TLA task refers to eliciting evidence from learners’ and teachers’ educational data in order to evaluate *specific elements* of their educational design. The *main aim* of this TLA task is to evaluate how the learners engaged with each element of the educational design (e.g., Ali et al. 2012) and use these analyses to support teachers answer relevant inquiry questions.
  - *Evaluation of overall educational design* (N = 18, x = 33.3%). This TLA task refers to supporting teachers to evaluate the impact of their *overall educational design* to learners. The *main aim* of this TLA task is to allow teachers to reflect on whether the intended educational objectives (e.g., knowledge, skills, attitudes) were successfully met by the learners (e.g., Smolin and Butakov 2012; Jaggars et al. 2016).

Table 2.7 Teaching and learning analytics tasks

#	Focus of reflection (TLA task)	Occurrence frequency (N = 54)	Percentage (%)
1	Evaluation of educational design elements based on educational data	41	75.9
2	Evaluation of overall educational design	18	33.3
3	Reflection on delivery of educational design	15	27.8

The teaching and learning analytics tasks were not mutually exclusive in each research work

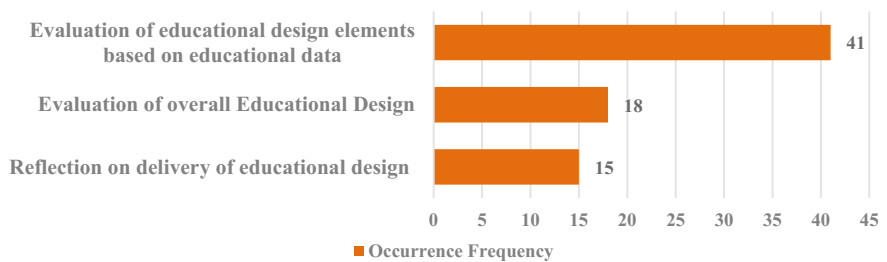


Fig. 2.7 Overview of teaching and learning analytics tasks

- *Reflection on delivery of educational design* (N = 15, x = 27.8%). This TLA task refers to supporting teachers to evaluate how they deliver the educational design. The *main aim* of this TLA task is to process teachers’ educational data from the delivery and provide insights for reflection and improvement of the way the teachers deliver their educational designs (e.g., van Leeuwen et al. 2014; Prieto et al. 2016).

**2.4.6 Results Related to Whether Teachers Were Provided with Recommendations for Supporting Reflection (RQ6)**

The RQ6 was aimed to elicit whether the existing TLA works deployed recommendations to facilitate teachers’ reflection and sense-making during the final step of the inquiry cycle (“Reflect on data”). In case that the TLA work did not offer such recommendations, the teacher had to engage in ‘ad-hoc’ reflective actions on how to utilize the analyses of the educational data. Table 2.8 presents the results of this analysis.

As Table 2.8 depicts, the majority of existing TLA works (N = 50, x = 92.6%) do not support teachers’ reflection and sense-making through recommendations for improvement. These works focus on either:

- Providing teachers with the analyses of the collected educational data without further decision support (e.g., Bos and Brand-Gruwel 2016). An example of such analyses can include a Social Network Analysis graph depicting the interactions of learners and teacher in the discussion activities (Dawson et al. 2008).
- Providing teachers with the analyses of the collected educational data and, further allowing the comparison between these analyses (e.g., Kladich et al. 2013; Bakharia et al. 2016). For example, Pardo et al. (2015) used regression analysis to identify the impact of different learner performance indicators

**Table 2.8** Analysis of TLA works in terms of whether they provided recommendations for reflection

#	Variables	Occurrence frequency (N = 54)	Percentage (%)
1	Provided recommendations	50	92.6
2	Did not provide recommendations (Ad hoc reflection)	4	7.4

(captured in educational data) on the level of their engagement for better understanding how to improve the educational design.

However, in both cases, the task of translating the results of the analyses or comparisons to actionable insights for improvement is performed by the teacher in an ad hoc manner. On the contrary, very few existing TLA works ( $N = 4$ ,  $x = 7.4\%$ ) support teachers in this final sense-making inquiry step. More specifically, these works mainly focused on either:

- Allowing the teacher to initially define questions on their educational design or delivery, which were answered by the TLA approach based on educational data from the delivery of the educational design. These insights were fed back to the teacher for informing their reflection and improvement actions (Martinez-Maldonado et al. 2016; Rodríguez-Triana et al. 2015).
- Generating textual feedback to the teacher using rule-based, pre-defined feedback templates that were populated based on the analyses of educational data (Kosba et al. 2005; Yen et al. 2015).

In both these cases, teachers received actionable insights, which described specific ways to improve their educational design and delivery. Considering the low number of the TLA works that offer recommendations to teachers, however, it is evident that the TLA state-of-the-art still rely on the teachers' capacity to translate data analyses to actionable insights during the "Reflect on data" inquiry step.

## 2.5 Discussion and Conclusions

Teaching and Learning Analytics is an emerging research field that aims to combine Teaching Analytics and Learning Analytics in order to support teachers during the process of inquiry. Considering the potential placed on this research field (Mor et al. 2015; Wasson et al. 2016), this book chapter performed the first systematic literature review in order to provide insights on how the state-of-the-art in TLA has realized this potential.

More specifically, using the concept of teacher inquiry and the model of the inquiry cycle as a backbone framework, a set of Research Questions were defined to capture and analyze the TLA research, identify trends (discussed in the previous section) as well as elicit overarching insights and/or shortcomings. The main insights and/or shortcomings from the SLR are as follows:

- The existing TLA works have mainly adopted *basic Teaching Analytics tasks (RQ1)*, which are related to depicting the elements of the educational design in a

transparent, but isolated, manner. Furthermore, the interconnections between these elements (e.g., the flow of learning and assessment activities) as well as the actual analysis and classification of these elements (e.g., classify learning activities to specific types) were accommodated in few research works. This insight suggests that existing TLA works provide limited support to teachers in terms of the range of inquiry questions they can potentially investigate, since they afford fragmented analysis of the educational design.

- The existing TLA works have accommodated the collection of a wide range of *learners' educational data* (RQ2). This diversity suggests that TLA research has largely exploited the potential of Learning Analytics to collect and process diverse types of learner educational data. This is also evident in the *data processing methods* (RQ4) for learner (and teacher) educational data, which are fully aligned with the approaches adopted in the Learning Analytics literature (e.g., Papamitsiou and Economides 2014).
- The aspect of collecting and processing *teachers' educational data* (RQ3) during the educational design and delivery process is addressed by few works. This is consistent with findings from the Learning Analytics field (Dyckhoff et al. 2013). The limited existing work is mainly focused to monitor teachers' contribution in learning and discussion activities. However, this is a significant shortcoming that can hinder teachers' capacity to reflect on their practice in a holistic manner, since it neglects capturing and evaluating their own actions.
- Regarding the *focus of reflection* (RQ5), the existing TLA works mainly aim to support teachers to target their inquiry in investigating the impact of their educational design to learner, both as a complete product as well as in specific elements of it. This is consistent with the concept of teacher inquiry, which engages teachers to investigate elements of their practice that they consider inefficient. However, few TLA works have explicitly addressed the aspect of supporting *teachers' reflection on the delivery of the educational design*. Following the previously mentioned shortcoming, this can be a hindering factor for holistic inquiry, since it neglects the significant factor of how the teacher actions during the delivery of the educational design can impact its effectiveness to learners.
- Finally, the SLR highlighted that little research attention has been placed on *providing recommendations* (RQ6) to teachers for translating the analyzed data to actionable reflecting actions on their educational design and delivery. This is an important challenge to tackle because the process of eliciting actionable insights for improvement is commonly considered a cumbersome task for teachers (Marsh and Farrell 2014; Mor et al. 2015). Therefore, providing teachers with evidence-based recommendations to translate data analyses to specific reflective insights, can be considered an important need for the TLA research field.

Overall, the contribution of the book chapter was to collect and analyze the existing research works in the emerging research field of TLA in order to understand and elicit the main trends and limitations. As the above discussion of the results indicated, the field of TLA is still in its infancy, with a heavy reliance on exploiting the existing Teaching Analytics and Learning Analytics methods and tools. However, new methods and tools to explicitly address the scope of TLA are yet scarce. Therefore, future research in the TLA field should build on the aforementioned insights and focus on proposing methods and tools that will address the shortcomings to extend the current state-of-the-art. Additionally, further analyses of the identified pool of research works can also be performed in order to elicit more sophisticated correlations and interconnections between the research focal points, methodologies and outcomes. As a result of the above, new TLA approaches for holistically supporting the full cycle of teacher inquiry can be introduced, aiming to support teachers engage in this important process and improve the teaching and learning conditions for themselves, as well as their learners.

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## Appendix

Table 2.9 depicts the full analysis of the 54 identified TLA research works, in terms of the Research Questions of the systematic literature review.

**Table 2.9** Analysis of research works included in the SLR

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
1	Agudo-Peregrina et al. (2014)	Customizable list of educational data	Engagement in discussion activities	Association rule mining—regression—statistics	Statistics	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data + reflection on delivery of educational design	Ad hoc
2	El-Bishouty et al. (2015)	Engagement in learning activities—assessment score—engagement in discussion activities	—	Clustering—classification—statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
3	Camilleri et al. (2013)	Engagement in discussion activities—assessment score—engagement in learning activities	—	Statistics	—	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data	Ad hoc
4	Chounta and Avouris (2016)	Engagement in learning activities—assessment score	—	Classification	—	Analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data	Ad hoc
5	Dawson (2010)	Engagement in discussion activities	Engagement in discussion activities	SNA—statistics	SNA	Analysis of ED in terms of elements	Reflection on delivery of educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
6	Fernández-Delgado et al. (2014)	Assessment Score	–	Classification—statistics	–	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
7	Fernández-Gallego et al. (2013)	Engagement in learning activities	–	Classification	–	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
8	Gómez-Aguilar et al. (2015)	Engagement with educational resources/tools—engagement in discussion activities	–	Classification	–	Analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data	Ad hoc
9	Govaerts et al. (2011)	Engagement with educational resources/tools—(time spent) engagement in learning activities—engagement in discussion activities	–	Statistics	–	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
10	Haya et al. (2015)	Engagement with educational resources/tools—engagement in discussion activities—assessment score	–	SNA—text mining—statistics	–	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data + reflection on delivery of educational design + evaluation of overall educational design	Ad hoc
11	Hernández-García et al. (2015)	Demographics—assessment score—engagement in discussion activities	Engagement in discussion activities	SNA—statistics	SNA	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
12	Howlin and Lynch (2014)	Engagement with educational resources/tools—engagement in learning activities—assessment score—engagement in discussion activities	Engagement in discussion activities	Statistics	Statistics	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data + reflection on delivery of educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
13	Kladich et al. (2013)	Customizable list of educational data	—	Statistics—association rule mining	—	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
14	Kosba et al. (2005)	Customizable list of educational data	—	Clustering—statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Recommendations for feedback
15	Marcos-García et al. (2015)	Engagement with educational resources/tools—engagement in learning activities—engagement in discussion activities	Engagement in learning activities—engagement in discussion activities	SNA	SNA	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data + reflection on delivery of educational design	Ad hoc
16	Mazza et al. (2012)	Engagement in discussion activities—assessment scores—engagement with educational resources/tools—engagement in learning activities	Engagement in discussion activities—engagement in learning activities	Statistics	Statistics	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data + reflection on delivery of educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
17	Mazza and Dimitrova (2007)	Engagement in discussion activities—assessment scores—engagement in learning activities	—	Statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
18	Mazza and Milani (2005)	Customizable list of educational data	—	Classification	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
19	Mendez et al. (2014)	Assessment score	—	Clustering—statistics	—	Analysis of ED in terms of elements	Evaluation of overall educational design	Ad hoc
20	Minović et al. (2015)	Engagement with educational resources/tools—engagement in learning activities—assessment score	—	Statistics	—	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
21	Mirriahi and Dawson (2013)	Engagement with educational resources/tools—engagement in learning activities—assessment score	—	Statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
22	Monroy et al. (2015)	Engagement in learning activities	Engagement in learning activities	Statistics—regression	Statistics—regression	Analysis of ED in terms of elements	Reflection on delivery of educational design	Ad hoc
23	Romero et al. (2008)	Customizable list of educational data	—	Statistics, classification, clustering, association rule mining	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
24	Slotta et al. (2013)	Engagement in learning activities—physical setting—assessment score—engagement with educational resources/tools	—	Classification—clustering	—	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data	Ad hoc
25	Smolin and Butakov (2012)	Assessment score	—	Association rule mining—statistics	—	Analysis of ED in terms of elements	Evaluation of overall educational design	Ad hoc
26	Schwarz and Asterhan (2011)	Engagement in discussion activities	Engagement in discussion activities	Classification—SNA	Classification—SNA	Analysis of ED in terms of elements	Reflection on delivery of educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
27	van Leeuwen et al. (2014)	Engagement in discussion activities—engagement in learning activities	Engagement in discussion activities	Text mining—statistics	Statistics	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Reflection on delivery of educational design	Ad hoc
28	Yen et al. (2015)	Engagement in discussion activities—engagement in learning activities	–	Statistics—text mining	–	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data	Recommendations for feedback
29	Zhang et al. (2007)	Engagement in discussion activities—engagement in learning activities—engagement with educational resources/tools	–	Statistics	–	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
30	Bakharia et al. (2016)	Engagement in discussion activities—engagement in learning activities—engagement with educational resources/tools—assessment scores	–	Clustering—association rule mining—SNA	–	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities + analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
31	Bos and Brand-Gruwel (2016)	Engagement with educational resources/tools—assessment scores—student behavior	—	Statistics—regression	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
32	Dawson et al. (2008)	Engagement with educational resources/tools—engagement in discussion activities	Engagement in discussion activities	SNA—Statistics—Clustering	SNA—statistics—clustering	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data + reflection on delivery of educational design	Ad hoc
33	Dunbar et al. (2014)	Demographics—assessment score—student behavior—engagement in learning activities—engagement with educational resources/tools	—	Regression—clustering—statistics	—	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities + analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
34	Duque et al. (2015)	Customizable list of educational data	—	Statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
35	Elbadrawy et al. (2014)	Assessment scores —engagement in discussion activities— engagement with educational resources/tools	—	Regression— classification —clustering —statistics	—	Analysis of ED in terms of elements + analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
36	Fritz (2016)	Assessment scores —engagement in discussion activities— engagement in learning activities —engagement with educational resources/tools	—	Statistics	—	Analysis of ED in terms of elements + analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
37	Hung et al. (2012)	Customizable list of educational data	—	Clustering— association rule mining— statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
38	Jaggars et al. (2016)	Assessment scores —engagement in learning activities —engagement with educational resources/tools	Engagement in discussion activities	Statistics	Statistics	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities + analysis of learning and assessment activity types	Evaluation of overall educational design	Ad hoc
39	Karkalas et al. (2016)	Engagement in learning activities —engagement with educational resources/tools	—	Clustering—statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
40	Martinez-Maldonado et al. (2016)	Assessment scores —engagement in learning activities —engagement with educational resources/tools	Engagement in learning activities	Clustering - Statistics	Statistics	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data + reflection on delivery of educational design	Mapping of educational data analysis to initial design questions
41	Merceron (2012)	Customizable list of educational data	—	Clustering—association rule mining—statistics	—	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
42	Ochoa (2016)	Assessment scores	–	Clustering—statistics	–	Analysis of ED in terms of elements	Evaluation of overall educational design	Ad hoc
43	Prieto et al. (2011)	–	Engagement in learning activities	–	Clustering—statistics	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities + analysis of learning and assessment activity types	Reflection on delivery of educational design	Ad hoc
44	Rienties et al. (2015)	Assessment scores —engagement in learning activities —engagement with educational resources/tools	–	Clustering—statistics	–	Analysis of ED in terms of elements + analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
45	Pardo et al. (2015)	Assessment scores —engagement in learning activities —engagement with educational resources/tools	–	Regression—clustering—statistics	–	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
46	Toetenel and Rienties (2016)	Assessment scores —engagement in learning activities —engagement with educational resources/tools	—	Clustering— statistics	—	Analysis of ED in terms of elements + analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data + evaluation of overall educational design	Ad hoc
47	van Leeuwen et al. (2015)	Engagement in learning activities —engagement with educational resources/tools— engagement in discussion activities	Engagement in discussion activities	Visualization —text mining —regression	Statistics	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Reflection on delivery of educational design + evaluation of educational design elements based on educational data	Ad hoc
48	Rodriguez-Triana et al. (2015)	Customizable List of educational data	—	Statistics	—	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities + analysis of learning and assessment activity types	Reflection on delivery of educational design	Mapping of educational data analysis to initial design questions
49	Wong and Lavrencic (2016)	Assessment scores	—	Statistics	—	Analysis of ED in terms of elements	Evaluation of overall educational design	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
50	Prieto et al. (2016)	–	Engagement in learning activities — location/physical data	–	Clustering—classification —statistics	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities + analysis of learning and assessment activity types	Reflection on delivery of educational design	Ad hoc
51	Ali et al. (2012)	Assessment scores —engagement in learning activities —engagement with educational resources/tools— engagement in discussion activities	–	SNA—classification —association rule mining—statistics	–	Analysis of ED in terms of elements + Capturing the flow of learning and assessment activities	Evaluation of educational design elements based on educational data	Ad hoc
52	Dyckhoff et al. (2012)	Customizable list of educational data	–	Statistics—regression	–	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities + analysis of learning and assessment activity types	Evaluation of educational design elements based on educational data	Ad hoc

(continued)

Table 2.9 (continued)

#	Reference	Learner educational data collected (RQ2)	Teacher educational data collected (RQ3)	Data analysis method for learner (RQ4)	Data analysis method for teacher (RQ4)	Teaching analytics method employed (RQ1)	Reflection focus (RQ5)	Recommendations/ad hoc (RQ6)
53	Fulantelli et al. (2015)	Customizable list of educational data	–	Statistics	–	Analysis of ED in terms of elements	Evaluation of educational design elements based on educational data	Ad hoc
54	Melero et al. (2015)	Assessment scores —physical setting	–	Statistics	–	Analysis of ED in terms of elements + capturing the flow of learning and assessment activities	Evaluation of overall educational design	Ad hoc

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