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USING THE REVISED BLOOM’S TAXONOMY TO SCAFFOLD STUDENT LEARNING IN BUSINESS INTELLIGENCE/BUSINESS ANALYTICS

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Abstract

The paper aims to make theoretical and practical contributions to the field of Business Intelligence/Business Analytics (BI) education, by addressing the following practice-inspired, teaching-related research question: “How to design learning activities to “scaffold” student learning in Business Intelligence (Business Analytics) towards more advanced cognitive and knowledge dimensions, and along the way help students to further develop their meta-cognitive skills of learning how to learn? The paper adopts the Revised Bloom’s taxonomy as a theoretical framework and demonstrates its use in design and implementation of BI-related learning activities at different levels of cognitive and knowledge dimensions. The paper also offers some research contributions related to the framework itself, in particular perceived correlation of different levels of cognitive process and knowledge dimensions, not captured by the Revised taxonomy.

Keywords: Business intelligence (BI), Business Analytics, Teaching Practices, Educational research
Introduction

Organizational applications of Business Intelligence (BI) continue to create new business and technology-related issues, often found at various priority lists worldwide (Gartner, 2010). This in turn continues to fuel the unprecedented demand for BI-educated professionals across different domains (Conway and Vasseur, 2010).

Business intelligence (BI) can be defined as “an umbrella term that is commonly used to describe the technologies, applications and processes for gathering, storing, accessing, and analyzing data to help business users make better decisions.” (Wixom and Watson, 2010, p.14). While some researchers and practitioners use the term BI for “business reporting” or “BI technology”, and “Business Analytics” for more advanced applications of analytical tools, we adopt a broader view of BI, as recommended by Wixom and Watson (2010). Thus, we consider Business Analytics to be a more advanced type of BI applications or as Eckerson (2004) suggested Level 5 of BI tool evolutions (with BI-enabled reporting being at Level 1).

With BI now reaching a more mature stage and evolving beyond technology, the levels of skills and knowledge required to fulfil previously unknown BI roles are expected to diversify even further - especially when it comes to BI-related management capability. “The fact is BI technology is now at a maturity stage… Business Intelligence, the management capability, needs to replace BI technology” (Bertram, 2010, p.23). At the same time, this is expected to be very challenging, because the level of skills required to take a more holistic approach to business performance that goes beyond BI technology, is still quite low (Conway and Vasseur, 2010).

In their quest to meet the industry demands and educate the BI workforce of the future, university educators world-wide are facing numerous challenges (Wixom and Ariyachandra, 2011; Wixom, Watson et al., 2011). The more obvious ones are related to fast-changing BI content, complex technology needed for BI classrooms, still-evolving body of disciplinary knowledge and an ongoing shortage of high-quality teaching resources. Even more complex issues are related to teaching “know-how” i.e. the best practices how to deliver BI content to students in a most effective way to help them to develop higher-order learning skills well beyond factual knowledge. This is critical for BI, given the fact that in this evolving area, factual knowledge has a very short half-life and, therefore, students need to be prepared for yet-to-be invented BI environments (May, 2010).

“An inability to provide relevant and meaningful problems for students to solve” remains one of the key challenges today (PRNewswire, 2010; TUN, 2011). This challenge is now even more intensified by the fact that BI-related content and activities need to be included in a number of different courses and delivered to very diverse cohorts of students (TUN, 2011).

Indeed, while in the past the main emphasis was on specialised courses, BI Educators now recognise that BI-related content and activities need to be designed and delivered across undergraduate and postgraduate curricula. This may include introductory Information Systems (IS) courses, specialised BI courses at the undergraduate and postgraduate levels as well as MBAs and Executive education. All these students need to become at least BI-aware as businesses are becoming increasingly BI-enabled. “Fifteen years ago, BI and enterprise systems were the domain of the technical elite. … Now firms strive for information democracy, all levels of the organisation are using business intelligence.” (Conway and Vasseur, 2010, p.37).

Looking from the educational perspective, this creates an additional dimension for the above-mentioned problem of “creation of relevant and meaningful problems for students to solve”, as their problem-solving skills will be very diverse across different courses and educational levels (e.g. undergraduate versus postgraduate). Furthermore, regardless of the starting point, these skills need to be gradually improved, not only within a single course, but also progressively over several courses. For example, this progression needs to be designed to start from an introductory information systems course, where students become BI-aware, all the way to the specialist BI course, where they become
more BI proficient. This particular requirement calls for domain specific teaching methods, designed to “scaffold” student learning, progressively introducing more and more complex activities, while building their skill set, as well as their confidence to tackle more complex problems.

In addition to scaffolding student learning, another important requirement for teaching in BI, or any evolving discipline, is to help students to develop the so-called “meta-cognitive” learning skills e.g. their ability to learn how to learn (May, 2010). “We are currently preparing students for jobs that don’t yet exists, using technologies that haven’t been invented, in order to solve problems we don’t know are problems yet.” (Fisch et al., 2011).

This requirement has also been confirmed by very recent business literature. “One of the major changes defining the new competitive environment is the requirement to know more about knowing. You are going to have to expand your ability to think critically about your own thinking. Experts sometimes refer to this as meta-cognition: knowing about knowing” (May, 2010, pg. 27). This is also supported by the latest research on executive decision making that puts one’s ability to engage in “thinking about thinking”, as the best predictor of good judgment, better than one’s intuition, experience or intelligence (Lehrer, 2008).

These two challenges of BI Education call for a systematic approaches, well founded in educational theories and informed by the current industry and teaching practices rather than ad-hoc solutions. The statement by Biggs (1999) still holds true due to the emerging nature of this discipline. “This is where many tertiary teachers are lacking: not in theories relating to their content disciplines, but in well-structured theories, relating to teaching their discipline” (Biggs, 1999, p.34). This certainly applies to the field of BI education as confirmed by two consecutive world-wide surveys of BI educators (Wixom and Ariyachandra, 2011) and (Wixom, et. al., 2010).

This paper aims to make theoretical and practical contributions to the field of BI education, by addressing the following practice-inspired, teaching-related research question:

*How to design learning activities to “scaffold” student learning in Business Intelligence (Business Analytics) towards more advanced cognitive and knowledge dimensions, and, along the way help students to further develop their meta-cognitive skills of “learning how to learn”?

More specifically, this educational research aims to explore and contribute to addressing the following challenges:

- How to scaffold students’ BI learning activities to help them to move beyond factual knowledge towards higher cognitive levels?
- How to scaffold this experience across one or more than one course?
- How to help students to become more aware of their meta-cognitive processes in order to improve their abilities to “learn how to learn” in the BI context?
- How to create engaging and meaningful learning activities in the BI context and teach more advanced BI topics to students without prior business and/or BI experience?

Even though this work focuses on a specific teaching area (BI), we argue that the same challenges apply to Information Systems (IS) teaching in general. However, the need for such a work is even greater in the emerging areas of IS such as BI, as confirmed by (Wixom and Ariyachandra, 2011) and (Wixom, et. al., 2010).

The paper is organized as follows. Section 2 introduces a theoretical framework used to guide and evaluate the learning activities described in Section 3. Section 4 offers an in-depth analysis of these activities, aiming to demonstrate how they address the stated research question. Section 5 summarises the main lessons learned in relation to the BI teaching know-how as well as some research contributions in the form of new requirements for the theoretical framework itself. Section 6 offers some conclusions and directions for future teaching-related research in BI.
2 Theoretical framework

Bloom’s taxonomy (Bloom et. al., 1971; Bloom, 1956) offers a systematic classification of different cognitive levels of learning. According to this well-known and widely used framework, learning could occur at six different levels termed: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. Related research has confirmed that after almost five decades of using this taxonomy, a majority of test (assignment/exam) questions given to students remain at the lowest level of cognition, requiring them to memorise and recall facts (Anderson and Krathwohl, 2002).

Even though it is still widely used today, Bloom’s taxonomy did require some important revisions in order to capture new insights created by the changing nature of knowledge, new modes of learning, emergence of new applied disciplines and new technologies (Anderson et. al., 2002). Most importantly, our collective understanding of various levels of cognitive and knowledge dimensions of student learning has been considerably improved since mid 50s when the original taxonomy was introduced. The outcome is the so-called Revised Bloom’s taxonomy (here termed the “Revised taxonomy”), previously designed by Anderson et al (2002) and shown by Table 1.

While the original Boom’s taxonomy had only one dimension, the Revised taxonomy includes the knowledge and the cognitive process dimensions. Also compared to the original cognitive levels, the cognitive process dimension goes beyond evaluation to capture an even more advanced level termed “Create”. When combined, these two dimensions enable educators to express an even richer set of learning objectives in order to guide students’ learning experience from one level to another.

<table>
<thead>
<tr>
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Table 1. The Revised Bloom’s taxonomy by Anderson et. al. (2002)

Briefly, the knowledge dimension of the Revised taxonomy (Anderson et. al. 2002) includes the following levels:

A. Factual knowledge: This level includes the basic elements of a teaching discipline, such as knowledge of terminology, basic terms and facts – all required to give students the basic vocabulary to even start learning.

B. Conceptual knowledge: This type of knowledge enables students to understand how different basic elements function together within a larger structure. This includes knowledge of models, frameworks, classifications, categories etc.

C. Procedural knowledge: This includes subject-specific methods, procedures, algorithms, techniques, all describing how to do something, as well as the knowledge of criteria for determining when to use the most appropriate procedures.

D. Meta-cognitive knowledge: This complex level captures many aspects of learning how to learn, including awareness of one’s own knowledge level and one’s cognitive approaches to learning required for different tasks.
The cognitive process dimension includes the following levels (Anderson, et. al, 2002):

1. *Remember:* consists of locating and retrieving mostly factual data from the long-term memory that is consistent with the presented material.
2. *Understand:* requires a learner to construct meaning from instructional materials through the processes such as: interpreting, exemplifying, classifying, summarising, inferring, comparing and explaining.
3. *Apply:* requires a learner to execute (i.e. apply a known procedure to a familiar task) or implement (e.g. apply a known procedure to an unfamiliar given task).
4. *Analyse:* requires a learner to break material into its integrative parts and then determine how these parts relate to each other, and to the whole, via processes such as differentiating, organising and attributing.
5. *Evaluate:* requires a learner to make a judgment based on previously acquired knowledge of the relevant criteria and standards. Evaluation includes processes such as detecting inconsistencies, assessing the effectiveness of the procedure being implemented, critiquing, judging etc.
6. *Create* includes reorganising the elements into a new structure or pattern, devising a new procedure to accomplish a task, inventing a new product etc.

As one could observe from the above brief explanation, the Revised taxonomy appears to omit important processes such as “problem solving” and “critical thinking”. Anderson et.al. (2002) argue that the objectives that involve problem solving and/or critical thinking require cognitive processes in several categories of the knowledge and cognitive process dimensions. For example, critical thinking requires some conceptual knowledge to start with, followed by in-depth analysis and evaluation of the identified issues. These steps may even result in a brand new perspective on the issue, thus taking students to an even higher cognitive dimension of Create.

The Revised taxonomy also enables its users to better position assessment items along the learning continuum, in order to gradually deepen students’ learning experience well beyond factual knowledge, towards more advanced levels. This particular point is very important in the BI field that involves a constantly changing context with new terms being invented on an ongoing basis. Focusing solely on the currently available content would make a significant portion of student’s learning quickly obsolete.

The following sections describe an application of the Revised taxonomy in the BI context. It demonstrates how to use this theoretical framework to design and implement learning activities in order to address the above stated requirements of BI education.

3 Methodology: Design of learning activities

The learning activities described in this paper were designed through an ongoing process of reflection-in-action. As pointed out by Schon (1983), the process of reflection on “how one might teach even better” is a basis of effective professionalism in many applied disciplines, including university teaching. Furthermore, “the process of reflecting on one’s teaching and seeing opportunities and areas for possible improvement, requires an explicit theory of teaching” (Biggs, 1999, pg. 6).

In our case, this explicit theory came in the form of the Revised taxonomy by (Anderson et.al, 2002), enabling the author (reflective practitioner) to scaffold students’ learning in BI, as well as guide and evaluate the design of the required learning activities. This design and evaluation process was implemented through several cycles of action learning (as suggested by Kember and Kelly, 1993). As previously noted by Biggs, “the learning part of action learning refers not only to student learning, or even learning about teaching, but to learning about oneself as a teacher, and learning how to use reflection to become better teacher” (Biggs, 1999, pg. 6).

As already stated, this approach has enabled the author to contribute to development and evaluation of the much needed but still evolving theories of teaching in BI. Even though there is a pressing need for such theories in the emerging disciplines such as BI (TUN, 2011), according to Biggs (1999) this need
is universal. This is because many tertiary teachers do not lack disciplinary content, they are lacking in “well structured theories relating to teaching their discipline” (Biggs, 1999, pg.6).

The following section introduces two examples of BI-related learning activities that are further analysed in the context of the Revised taxonomy in the subsequent sections of this paper.

4 Illustrative examples of BI learning activities

Two sets of BI-related questions (depicted by Fig. 1 and Fig. 2) were designed to help students to learn about CRM systems at two different levels: Set 1 for an introductory Information Systems (IS) course and Set 2 for a subsequent specialist BI course. Both sets were designed and used by the author and extensively evaluated over two years, as described later in the paper. The activities are chosen as illustrative examples and represent a very small sample of learning activities used in both courses. However, they are sufficient to demonstrate the principles of scaffolding and development of meta-cognitive skills, as intended by this paper.

To better demonstrate the scaffolding effect, both sets of activities are structured around the same educational resource – a video case called “Teradata Offer Management System” (Teradata, undated). This particular approach to learning design structured around the same resource is confirmed to help students to better establish and reinforce cognitive “anchors” and “construct meaning”, as demonstrated by the constructivists theory of learning (Jonassen, 1997).

As already indicated, Set 1 was used in an introductory IS course, with a very large group of business students, most of them without any prior business experience. The activity focuses on the topic of Customer Relationship Management (CRM) Systems that is probably one of the most challenging ones to teach at the introductory level, as most of the first year students have very little awareness, let alone experience in using these systems in practice. A typical textbook chapter is likely to offer lots of definitions, high-level architecture of a CRM system, along with a list of its main functions, very much reinforcing factual knowledge. This is often supplemented with the end-of-the-chapter questions that also tend to reinforce the same cognitive level, especially with numerous multiple-choice questions, mostly designed for the levels of recognition and recall.

Yet, as all educators teaching these classes know, “it does not work to teach the class like a geologist naming minerals. Here’s a TPS, here’s a MRP, here is an MRP II, here is an ERP, etc. Nor does it work to teach the class as a glorified dictionary” (Kroenke, 2005).

Furthermore, the effects of a learning experience structured around factual knowledge tend to be propagated to more advanced courses. In the case of a specialist BI course this is very likely to create additional challenges for both students and their teachers. This is because of a very dynamic nature of this emerging discipline requiring students to quickly progress towards more advanced levels of knowledge and cognitive processes, in order to make their skills transferable and acquired knowledge more sustainable.

The other effect on students’ perception about the whole Information Systems (IS) field - “it is all data and no information” (Kroenke, 2005) - is even harder to change, especially if students are exposed to new concepts and activities they cannot relate to. This is why another important design requirement for both sets of activities, especially at the introductory level, was to use very interesting, up-to-date, easy-to-relate examples – thus the chosen video of Teradata Offer Management System. The featured case illustrates a real-life application of a complex BI-enabled CRM in a supermarket, something all students can easily relate to.

The following section offers an in-depth analysis of these two sets of questions and illustrate the ways they have been used to scaffold students’ learning experience within a single course as well as across two courses (introductory and advanced).
### Set 1: A sample of questions used in an introductory IS course

<table>
<thead>
<tr>
<th>Q1</th>
<th>What is a <strong>CRM</strong> (Customer Relationship Management) System? Who are its typical users?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q2</td>
<td>List and briefly describe basic elements of a CRM? How do they relate to each other? Illustrate your answer by a high level (conceptual) model of CRM.</td>
</tr>
</tbody>
</table>
| Q3 | a) Who are the main users of the featured **Offer Management System**? How do they use this CRM system?  
   b) What types of decisions do these users make? |
| Q4 | a) Describe the main steps of the featured offer creation process.  
   b) How does this process relate to Simon’s decision-making process? |
| Q5 | Describe a model of Business Data Architecture likely to be used by the featured retail organization. |
| Q6 | Give an example of a vertical information flow from the transactional databases to the featured enterprise Data Warehouse. |
| Q7 | a) How does the offer management system enable personalization of customer interaction in the featured case?  
   b) As a customer, would you consider it to be effective?  
   c) How would you improve it? |
| Q8 | Identify a possible example of data mining likely to be used by the featured retail store. Justify your reasoning. |
| Q9 | *(lateral thinking)*: Can you think of any other business domain that could benefit from an application of the same (or similar) offer management system? Explain your reasoning. |

*Figure 1: An example of a learning activity suitable for an introductory level*

### Set 2: A sample of questions used in a specialist BI course

| Q10 | How would you assess the effectiveness of the featured system? |
| Q11 | Suppose that you were in charge of implementing a Data Quality program in the featured organization and your main focus was the featured Offer Management System.  
   a) What would be your main steps? How would you involve the existing CRM users?  
   b) How would you assess the effectiveness of your program? |
| Q12 | Can you think of any other business domain that could benefit from an application of the same (or similar) offer management system? What would be the main characteristics of a business domain that would be suitable for a possible application of the featured system? |

*Figure 2: An example of a learning activity suitable for a specialist BI course*
Using the Revised taxonomy to scaffold students’ learning experience

Table 2 illustrates a suggested mapping of the above-described sets of questions along the knowledge and cognitive process dimensions. Questions from Set 2 are shown in the bold typeface, to make it easier to observe the intended higher levels of cognitive and knowledge dimensions.

The featured examples do come from the BI field, however, we argue that the described pattern of analysis and design of learning activities, guided by the Revised taxonomy, does apply to any evolving discipline. In particular, those that also require students to develop skills for the future world of yet-to-be invented business problems and brand new technologies.

The analysis of the provided table yields several important observations related to the individual questions as well as patterns of their combinations that lead to more advanced cognitive levels. Thus, Q1 starts from factual knowledge and requires students to remember and recall a basic definition. This is a typical end-of-the-chapter question, quite useful to start from, for several reasons. For example, it could be used to set the scene and make sure that students have acquired the basic terminology, for example by reading a textbook. More importantly, when placed in the taxonomy table, the same question could be used to explain why the “textbook knowledge” is not sufficient in the BI context.

The next question (Q2) still focuses on the same cognitive process dimension (Remember) but goes beyond factual knowledge as it requires students to link different components of CRM together. Even though this is a relatively simple question, it builds the foundation for the future more advanced activities. Because without the basic terminology and understanding how these components relate to each other at the conceptual level, students are unable to recognise them in a real-life setting, let alone analyse and evaluate their organizational applications.

Moving along the cognitive process dimension, Q3a requires students to Understand the CRM definition in context of the given case study i.e. to identify the real users of the featured system. Q3b requires students to start from their own understanding of three different types of decision and then apply it to the given case in order to identify what type of decisions need to be made by different users.

<table>
<thead>
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<td>Q1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Conceptual knowledge</td>
<td>Q2b</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>C. Procedural Knowledge</td>
<td>Q4a</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>D. Meta-cognitive knowledge</td>
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Table 2: Analysis of the BI-related questions in Sets 1 and 2

Students focused on level 1 (Remember) are very unlikely to even recognise that the question relates to different types of decisions (i.e. structured, unstructured, semi-structured). A “scaffolding” question
that requires them to name and explain different types of decisions first, would certainly help them to apply this knowledge and recognise it in the given context. However, this approach would make Q3b easier and therefore “move” it to the lower cognitive process level – Understand rather than Apply.

Q4 relates to the procedural knowledge and its two components illustrate the difference between two cognitive dimensions (Understand and Analyse). Note that the required decision-making model had been previously introduced to students and used here to link different topics together. Q5 also focuses on the same cognitive process dimension (Analyse), but compared to Q4 illustrates a different knowledge dimension (in this case Conceptual knowledge), while Q6 focuses on the analysis of factual knowledge).

Compared to all previous questions, Q7 reaches much higher levels of cognitive dimensions, requiring students to analyse the existing system and evaluate its effectiveness (in a simple way), from a customer perspective. This is the context they can all relate to, being supermarket customers. They are then required to propose a possible improvement (Create) at a conceptual level. For example, they may say that personalised offers to the customers could be sent via mobile phone. This is a simple, but nevertheless, good example of possible improvement they could easily think of.

Q8 requires students to recognise a possible application of data mining used in the featured context, even though this particular term has never been explicitly mentioned in the featured video. They would need to analyse the case for possible “symptoms” of data mining applications being used, then use these insights to construct and justify their arguments for a possible case of data mining application.

Similarly to Q7c, Q9 requires students to think laterally and transfer their knowledge from one domain to another and Create new ideas - in this case identify possible application domains, again at the conceptual level. A probing question such as “Where else would you use such a system” could be used to guide their thinking.

As already noted, this transfer of knowledge across contexts, domains and applications is very important from the BI perspective, due to the fast changing nature of content. Most importantly, students are asked to explain their reasoning (Q9b) and provide a strong argument for another domain, rather than trying to guess it. This means they need to analyse their own idea, as well as the underlying thinking process.

All the above questions could be used in a learning activity offered in one week or spaced over several weeks to reinforce student learning. Most importantly, this relatively simple set of questions clearly illustrates scaffolding of student learning of complex BI applications in an introductory IS course. Due to the gradual increase of complexity and the cognitive levels, they are designed to move students’ learning experience further and further away from simple factual knowledge and recollection of these facts, often reinforced in the introductory courses, as pointed out by Kroenke (2005).

The same table also illustrates how student learning continues to develop in a more advanced BI course, building upon their prior experience. Thus, question Q10 starts from the evaluation of the factual and conceptual knowledge, assuming that students have already acquired the basic terminology in the introductory course. Different parts of Q11 illustrate another important point that the same question could be used to reinforce students’ learning across different dimensions (analyse, evaluate and create) in an iterative manner. It is important to note that this particular concept of “feedback loop” has not been captured by the Revised taxonomy that very much assumes a linear progression from a lower to the higher level.

Finally compared to question Q9b that also focuses on the meta-cognitive level, Question Q12 illustrates another point, again of fundamental importance for BI learning, especially at the advanced level. In this question, students are required not only to analyse their thinking processes and provide sound arguments for their proposed solution, but also to become aware of their thinking pattern. For example, rather than just identifying “telecommunications” as another industry or business domain where this system would be highly applicable, students may be able to provide an even higher-level
answer. For example, “any industry characterised by high volume transactions and a large number of repeating customers would be a suitable candidate”. This way of thinking would enable them to assess the applicability of the featured system in any domain, including those yet-to-be invented, making their knowledge transferrable to possible future contexts and scenarios.

6 Evaluation, reflection and educational research contributions

This section summarises some important lessons related to design of student learning activities in BI as well as the theoretical framework itself.

To ensure that the above-described approach did support scaffolding of students’ learning, different evaluation methods were designed and refined over time. First of all, students were required to provide feedback several times throughout each semester. Although students reported a “deeper level of understanding” and “improved learning”, the self-reported feedback was in fact found to provide a good insight into students’ perception of their own learning rather than an objective measure. Furthermore, in a specialised BI class, students were asked to reflect on their own learning by using reflective summaries as well as another reflection tool called “application cards” (outside of the scope of this paper). Their reflections were then mapped (as much as possible) against the Revised taxonomy showing an objective improvement of their ability to think about their own learning. Finally, and again in a specialised BI class (due to smaller numbers), all questions given in any formative and summative assessment items throughout the semester (including in-class quizzes, mid-session and final exams) where mapped against the Revised taxonomy. Then by tracking the quality of answers to each question (using the marks awarded), we were able to confirm that later in the semester more students were able to answer “higher-level” questions and with a greater depth. While it was hard to isolate the Revised taxonomy as the main reason for students’ improvement, it was certainly a contributing factor. Moreover, when asked during subsequent group feedback sessions, students themselves were able to position the questions within the taxonomy table with a higher level of accuracy and some of them even map their answers, indicating a higher level of awareness of their own learning. For example, a student provided the following feedback: “I now understand why textbooks are not sufficient to learn BI”. Another observed “This is Level 1A question!” placing another student’s question in the context of the Revised taxonomy (i.e. in (1, A) cell) to indicate how simple it was.

In an ideal situation, the Revised taxonomy could be easily used to enables “tracking” of each individual student and mapping of their progress throughout the semester. However, in our case this was not feasible and this is certainly a limitation of this study.

In addition to the student perspective, our evaluation also included the reflective practitioner’s (i.e. teacher’s) perspective. Every example of innovative use of the taxonomy and its effects, every conversation with students about the taxonomy and its applications, have been carefully documented. Over time, this collection of observations and insights enabled the author to derive some interesting patterns of applications as follows.

The Revised taxonomy does enable students and teachers to better “position” a particular learning activity in terms of its cognitive process and knowledge dimensions, and thus, better understand the intended learning objectives. Therefore, the revised taxonomy becomes a very effective knowledge sharing tool, prior, during and after learning activities.

Furthermore, it enables students to “trace back” and even visualise their learning journey, as well as map their own learning progress both in terms of the cognitive and knowledge dimensions. This, in turn is likely to improve their self-reflection skills and further develop their ability to self-assess and even calibrate their learning progress.

The Revised taxonomy could be also easily and effectively combined with other cognitive tools such as mind maps, to help students not only to connect different topics, as required at the Conceptual knowledge level (B), but also to better understand the nature of these connections. Further research is
required to find and evaluate the most effective ways to use mind maps at different levels of the Cognitive process dimensions.

In addition to facilitating knowledge sharing among the teachers and their students, the Revised taxonomy also facilitates the same knowledge processes among teachers, and across different courses. This project confirms that this method of knowledge sharing is much more effective than sharing of different weekly topics, as it determines with much more precision the exact levels of the cognitive process and knowledge dimensions for each topic and each activity within it. This in turn can be used to continue to scaffold students learning in subsequent and more advanced courses.

In addition to the above stated lessons related to BI teaching know-how, this work also makes several research contributions related to the revised taxonomy itself. They are related to the experienced “patterns” of progression across different levels of cognitive processes and knowledge as well as possible co-relation of different levels of these two dimensions.

More precisely, as students continue to improve their skills and knowledge, one would expect that they continue to progress from one level to the next. Consequently, the table is expected to be populated in a linear fashion across both dimensions (left-to-the right, top to the bottom). However, in practice, this is not exactly the case.

First of all, it is very hard to focus on development of meta-cognitive knowledge related to learning in a particular disciplinary domain, while students are still at lower level of the cognitive process dimension. In other words, if they are at Level 1 of the Cognitive process dimension (Remember), guiding them towards the meta-cognitive knowledge (i.e. Cell (1, D)), does not really hold. Therefore, rather than focusing on all four knowledge dimensions of the same Cognitive process dimensions, from the authors experience, it is possible to confirm that moving to the higher cognitive process dimension enables more rapid progression towards the meta-cognitive knowledge.

The second observation is related to the existence of “loops” among cells. As already illustrated, one question could be easily “spread” across several cells of the table and may require students to go through several iterations of analysis, evaluation and creation, as new creations need to be analysed and evaluated. Thus, every iteration becomes more and more complex due to the accumulated knowledge. This also means that students are not going back to the previous level, because they are losing some of their accumulated knowledge, but quite the contrary – the knowledge gets augmented. This particular aspect is not captured by the existing taxonomy and probably requires another dimension.

In addition to the above two patterns, further research is required to discover, analyse and possibly even predict more correlations between different levels of the cognitive process and knowledge dimensions. This is expected to lead to new types of learning activities that will support even better scaffolding from one level to another.

7 Conclusions and future work

The main objective of this paper was to contribute to finding a solution for an important practice-inspired, teaching-related research question:

“How to design learning activities to “scaffold” student learning in Business Intelligence (Business Analytics) towards more advanced cognitive and knowledge dimensions, and, along the way help them to further develop their meta-cognitive skills of learning how to learn?”

The paper uses the Revised Bloom’s taxonomy and demonstrates two BI-related learning activities, designed and used by the author to address the stated problem. The activities were used with very large groups of students and extensively evaluated as described above.

Even though this paper focuses on the BI contexts, the patterns of application of this important, but lesser known educational taxonomy are applicable to the other domains. However, in the BI context,
higher levels of the knowledge dimensions, combined with the higher levels of the cognitive process dimensions are considered to be even more important than in other less dynamic teaching disciplines. For example, the ability to recognize high-level patterns and create meaning from huge amount of data, in order to quickly assess the situation and take action, is now considered to be a critical component of the so-called “executive brain”. For “business executives trying to make sense of a rapidly changing business environment, superiority of pattern recognition is perhaps the greatest advantage that can be developed” (Gilkey and Kiltz, p.53).

Our current and future work in this area include further research of design patterns for new learning activities in BI, using the above described principles. This is expected to lead to further contribution to the effective practices and theories of teaching BI.

References


