Published with minor alterations in the
Proceedings of the Interactive Computer-Aided Learning Conference 2005. Kassel: University Press.

An Analysis of Learning Resources Using a Cognitive Process Taxonomy[1]

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Key words: *Learning Object, Information Object, Cognitive Process Taxonomy, Anderson & Krathwohl*

Abstract:

Learning objects should be viewed more critically, providing distinctive definitions for information objects and learning objects. One method to achieve a clearer differentiation is the judgement whether or not learning resources can be categorized using a taxonomy for cognitive processes, for instance, the one developed by Anderson & Krathwohl. Applying the taxonomy, an analysis of existing learning resources on the World Wide Web showed that two thirds of materials in a repository were information objects, which just presented information, while one third were learning objects. Of the materials categorized as learning objects, 82% supported the lower cognitive processes of the taxonomy.

1 What are Learning Objects?

The idea of learning objects has sparked many discussions within the e-learning community. Most definitions of learning objects concentrate on

- the aggregation and presentation of content, i.e. subject matter,
- the small granularity of learning objects compared to entire courses, and
- the requirement that learning objects have to be context-free to be reusable in different contexts (MASIE Center, 2002; Wiley, 2000; Weitl, Kammerl, Göstl, 2004; Murphy, 2004).

One popular definition of learning objects is the one Wiley proposed, “any digital resource that can be reused to support learning” (Wiley, 2000:7).

We find problematic, that learning objects are usually meant to just present some type of subject matter – the content – even though the definition could include scripts for learning scenarios. The focus on content with learning objects can be observed, for instance, when browsing through online learning object repositories[2]. Even the definition proposed by Wiley exclusively refers to content and information delivery, as can be extracted from his explanations for the definition and the examples he gave (Wiley, 2000:7f).

Also standards initiatives, which lay ground rules for the use of learning objects, have thus far been focusing on the content side of learning objects (cp. LOM by IEEE, 2002; SCORM by Advanced Distributed Learning Initiative, 2001). Only IMS Learning Design (IMS Global

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[1] This article was written in the context of the research project ‘CampusContent’ (http://www.campuscontent.de), which is sponsored by the DFG (Deutsche Forschungsgemeinschaft resp. German Research Foundation; http://www.dfg.de) under the code number 44200719.

[2] For example, Multimedia Educational Resource for Learning and Online Teaching –Merlot (www.merlot.org).

Learning Consortium, 2003) is an exception to the other standards because it explicitly includes learning activities as an implementation mechanism of learning objects.

Krause and Kortmann (2002:3) anticipate that the use of learning objects, the way they are currently structured with the focus placed on content presentation, will lead to a set-back in education and back to rote memorization of information. Similarly, Reinmann (2005:12) indicates the need for strategies for moving from reusable learning objects as content holders towards educating units of meaning. Along these thoughts, this paper examines whether learning objects found on the World Wide Web are actually information objects, meaning they present content, and what cognitive processes "real" learning objects support.

2 The Potential Pedagogy in Learning Objects

In this section, we will first illustrate the reduced view of learning objects as information delivery objects. Second, an alternative view will be presented that includes a focus on learning objects with special attention paid to the cognitive processes they support.

2.1 Viewing Learning Objects as Information Objects

Reducing learning objects to their function as information (delivery) objects has the following advantages:

- Information objects, if they are existing independently, can easily be aggregated into larger units of study. One model that proposes such an approach is the autodesk content model shown in Figure 1. In this approach, larger units of study, such as courses, are created by accumulating smaller units such as lessons. Lessons, on the other hand, are comprised of learning objects, which in turn are comprised of information objects. Units of study on the upper levels therefore represent great aggregations of information objects. This approach allows the reusability of information objects in different contexts.

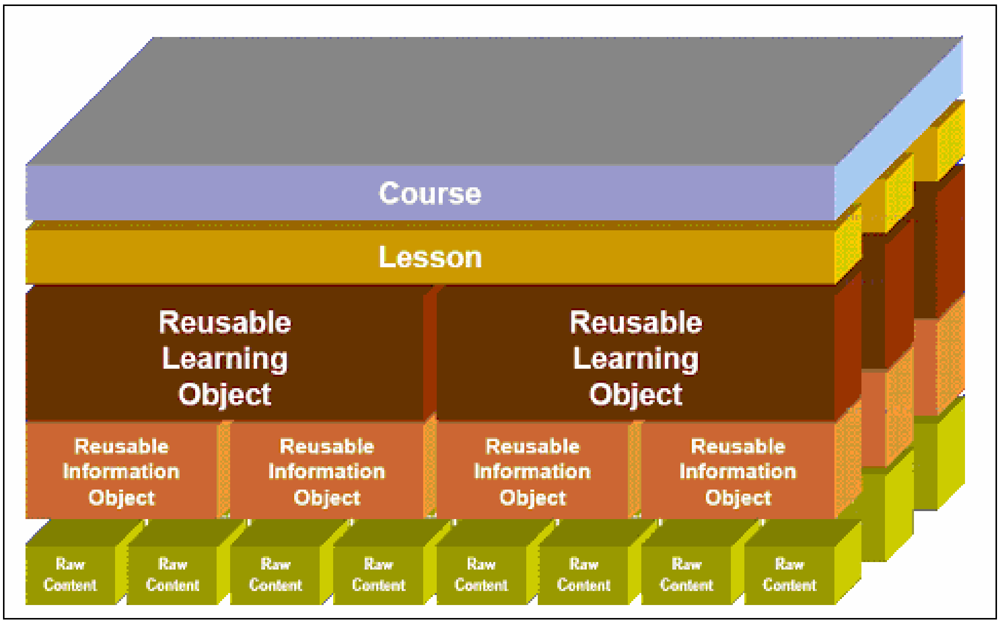

Figure 1: Autodesk Content Model (Adopted with slight modifications from Hodgins, 2001).

- Reducing learning objects to information objects also keeps the material flexible for educational purposes. Information objects, since they deliver subject matter, can be used flexibly in different academic settings. For instance, a picture of the Mona Lisa with an accompanying text explaining the picture and its interpretations (this would be the information object) could just as easily be used in an arts studies class as well as in a history class. Instructors in the arts course and history course may choose different activities to use with this specific information object. For instance, in arts, drawing a copy of the Mona Lisa with pencils only is an activity derived from the object; in history, the activity might be to compare the Mona Lisa and its interpretations with other Italian paintings from that era and draw relationships to historic events.
- If students are to memorize and recall certain information, information objects would serve this purpose. One way to achieve memorization is to present the material and let the learners memorize the material using their own strategies. Probably, drill & practice exercises could support the memorizing process, but activities to help “learn” the material are, per definition, not contained in information objects. Providing activities to support learning processes goes beyond the presentation of subject matter and hence *cannot* be part of an information object. This last statement shall be used as a distinctive feature between information and learning objects: information objects present information or subject matter, while learning objects include next to the content presentation some type of learning activity or learning objective. This shall be examined in further detail in the following sections.

As can be seen from this list, there are advantages to having “reduced” learning objects, i.e. information objects. Information objects can be assembled into larger units, they are reusable within different educational purposes, and they serve the memorizing and understanding process of the students.

2.2 Enriching Information Objects to Create True Learning Objects

Could the concept of information objects revolutionize e-learning? Perhaps this analogy will help answer the question: would it be enough to hand children books that contain all the necessary information and not have them go to school any longer? Just as much as we hold on to the concept ‘school’, we should not give up on learning aspects that go beyond the presentation of subject matter within the e-learning realm.

Learning is a process; in the case of e-learning, learning mostly involves cognitive processes. Now, problematic is that the delivery of information and content via information objects pushes the learning *process* to the back. Why is this problematic? The presentation of content, although not explicitly stated, implies that students are to “recall” or “understand” the materials.

Understanding and recalling knowledge belong to the paradigm of *transferring knowledge* – a traditional view on how people learn. This traditional paradigm of education has nowadays been revised to a process, where the learner cognitively rebuilds the knowledge (Mayer, 1992; Winn & Snyder, 1996 cited in Koper, 2003). Cognitive rebuilding of knowledge, however, requires educational methods and activities besides the mere presentation of subject matter.

Therefore, in order for learning objects to be called *learning* objects, they need to include some type of process that is associated with learning, for instance, a learning objective, or better, a learning activity. If learning objects expressed the cognitive processes that are associated with them, instructors and learners could more easily organize learning objects, thus reusing them with their intended purpose. This is the distinguishing feature of a learning object: The learning object expresses its intent through activities or learning objectives while the information object merely presents subject matter without an indication of associated cognitive processes.

Learning activities include a wide range of practices that students can engage in to support the learning process. Activities include large frameworks like problem-based or project-based learning, which require assemblies of activities, as well as less complex activities like multiple-choice tests or summary writing.

Learning objectives generally serve the planning process of instructional design by making the wanted outcomes of learning explicit. There are different types of learning objectives, whose function depends on the level that the learning objective describes (course, module, lesson, activity). Learning objectives usually consist of two fundamental elements: a (cognitive) process and a knowledge specification (Anderson & Krathwohl, 2001:12; cp. Nitko, 2004:16; Meder, 2003:56). Traditional and more behaviorist-oriented models of learning objectives furthermore include the conditions under which the process is to be performed as well as an assessment instrument and criteria, with which the attainment of the learning objective is to be measured (Schüpbach, Guggenbühl, Krehl, Siegenthaler, Kaufmann-Hayoz, 2003:127). For the purposes of this paper, the first definition is adopted, reducing learning objectives to a cognitive process, which relates to a knowledge specification.

Learning objectives, activities and assessments can usually be placed into a categorizing scheme called taxonomy of cognitive processes. The taxonomy helps educators to plan and organize their instruction, especially to ensure that the instruction includes different levels of cognitive processing. One of these taxonomies will be introduced in the following section.

3 A Taxonomy for Learning, Teaching and Assessing: Anderson & Krathwohl

Taxonomies are classification agents. The most commonly known taxonomy may be the phylogenetic framework: it categorizes mammals, birds, arthropods and so forth by their distinguishing body features and living characteristics. The purpose of the phylogenetic taxonomy is that when an animal is placed into a certain category, we can infer certain characteristics of that animal just by knowing its category within the taxonomy. For instance, if we know that whales are mammals, we can immediately conclude that they must be air-breathing, warm-blooded, nursing their young, and have a larger and more developed brain (Anderson & Krathwohl, 2001:4).

Similarly, learning outcomes with regard to cognitive processes have been categorized into a taxonomy of cognitive processes. The most widely known and used taxonomy in this context is the one by Bloom (1956). This taxonomy of the classification of student learning outcomes was first developed to “promote the exchange of test items, testing procedures, and ideas about testing” (Anderson & Krathwohl, 2001:XXXVII). Since its publication, Bloom’s handbook including the taxonomy has been translated into more than twenty languages (Krathwohl, 1994 cited in Anderson & Krathwohl, 2001:XXI). Anderson and Krathwohl revised Bloom’s popular taxonomy of the cognitive domain by including newer findings in cognitive and educational research. Table 1 gives an overview of the revised taxonomy.

The Knowledge Dimension	*The Cognitive Process Dimension*					
	Remember[3]	Understand[4]	Apply[5]	Analyze[6]	Evaluate[7]	Create[8]
Factual Knowledge						
Conceptual Knowledge						
Procedural Knowledge						
Metacognitive Knowledge						

Table 1: Taxonomy of cognitive processes by Anderson & Krathwohl (2001).

Revisions that Anderson & Krathwohl administered were switching from noun-stated categories to verb-stated categories, thus, relating the taxonomy more to the *processes* behind cognition. Second, they changed some of the higher level categories, reflecting newer findings in educational and cognitive research. Last but not least, Anderson & Krathwohl added a second dimension – the knowledge dimension – to their revised version of Bloom's taxonomy.

The cognitive process dimension is listed from the lowest level (Remember) to the cognitively highest level (Create), while higher levels integrate the levels below them. The knowledge dimension also reflects increasing accumulations, i.e. facts are contained in concepts, concepts are contained in procedures. Only metacognitive knowledge is an exception as Anderson & Krathwohl themselves stated.

Practitioners use the taxonomy of cognitive processes to categorize and align learning objectives, learning activities and assessment instruments, thus, organizing them. Using this procedure, instructors realize what categories the wanted learning procedures belong to, if there is adequate differentiation between learning objectives and what testing procedures will be appropriate to use. This way, instructors can ensure that, for instance, higher order learning processes are not neglected.

There is a general critique regarding taxonomies saying they are artificially constructed frameworks (cp. Foucault, 1974, esp. p. 191). We do not claim that the introduced taxonomy by Anderson & Krathwohl provides an actual frame of reference that corresponds to reality, but we do want to emphasize the consonance of the taxonomy and its heuristic meaning for the development of learning resources.

[3] Retrieving relevant knowledge from long-term memory.
[4] Construct meaning from instructional messages, including oral, written, and graphic communication.
[5] Carry out or use a procedure in a given situation.
[6] Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose.
[7] Make judgments based on criteria and standards.
[8] Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure.

4 The Analysis of Learning Resources Using Anderson & Krathwohl

4.1 Description of the Analysis

The goal of our analysis was to find out, how learning objects on the World Wide Web could be placed into the categories of the cognitive process taxonomy by Anderson & Krathwohl (2001). This served as a method to make the (mostly implicit) pedagogical framework in learning objects visible. The resulting distribution was to be used as an indication, what cognitive processes learning objects could support, especially questioning whether learning objects support the higher cognitive processes (categories Analyze, Evaluate and Create).

University of Bern scientists already used a similar procedure to evaluate their own learning objects (Knolmayer & Montandon, 2003), yet, they used Bloom's taxonomy of cognitive processes (1956) instead of the revised version by Anderson & Krathwohl (2001). Knolmayer and Montandon stated that their developed learning objects covered every category within Bloom's Taxonomy. Had they used the taxonomy by Anderson & Krathwohl, however, their objects would only have fulfilled criteria for five of the six categories, leaving out the highest. For the reasons named above, namely the inclusion of newer results of cognitive research, for this analysis the revised taxonomy by Anderson & Krathwohl (2001) and a wider range of materials shall be used.

The learning resources in this analysis were taken from a repository of learning materials: Merlot (http://www.merlot.org). This database was used because it has already acquired a large number of learning materials and resources. Using the browsing function within Merlot, materials were taken from the "Science and Technology" section (5123 items on August 18, 2005).

The reason for preferring Merlot was that Merlot implemented an editorial board reviewing system that provides a qualitative rating of materials. The reviewers give marks in the categories content quality, potential effectiveness as a teaching tool, and ease of use for students and faculty. Furthermore, Merlot labels special materials using "Editor's Choice" as well as "Merlot Classics" tags. Only items that received an overall peer review rating higher than 4.5 out of 5 were used. Learning objects were taken from the top down in the order they were presented when starting to browse. The order of learning objects reflected a decreasing value for the rating.

Important regarding the analysis was also the distinction between information objects and learning objects. This distinction was made as described earlier: if no learning activity or learning objectives were included, the resource was classified as an information object. If the resource included some type of activity and learning objective besides the content presentation, the resource was classified as a learning object and additionally received a categorization according to the Anderson & Krathwohl Taxonomy. However, a categorization was only applied for the cognitive process dimension of the taxonomy (Remember, Understand, etc.) omitting a categorization in the knowledge dimension (factual knowledge, conceptual knowledge, etc.). This served the purpose of specifically looking at the cognitive processes that online learning resources support.

Two examples shall be used as a demonstration for this classification and categorization process. Figure 2 shows an example of a resource, whose main purpose is to present subject matter, in this case the anatomy of primates and humans. There are no learning objectives or activities included with this resource. Therefore, it was classified as an information object. The Merlot peer reviewers gave this resource a rating of 5.0.

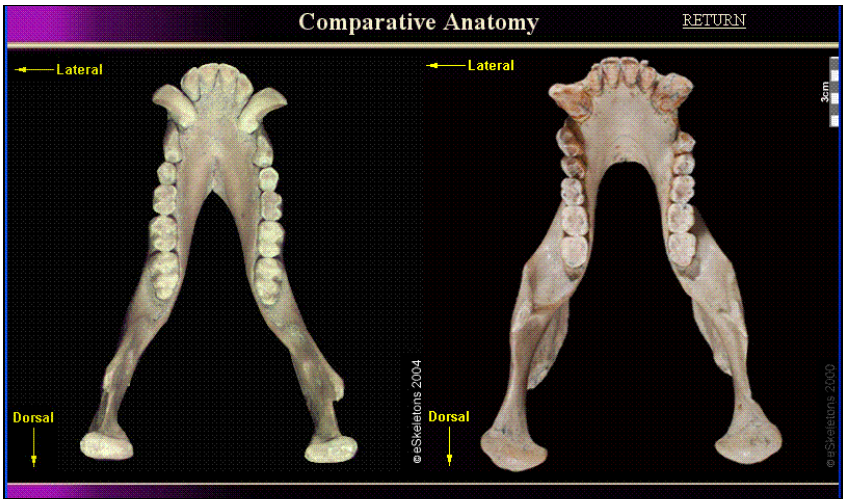

Figure 2: Information Object that graphically contrasts bones of different primates[9].

The second example is shown in the following two figures. The screenshots portray two sections of a Flash animation: Figure 3 shows the first part of the resource (the one responsible for presenting the information), while Figure 4 shows the part of the resource that actually contains a learning activity. Therefore, the entire Flash animation was classified as a learning object. Taking a closer look at the learning activity, the cognitive process supported is "Evaluate" because it fits the criterion "detecting the appropriateness of a procedure for a given problem" (Anderson & Krathwohl, 2001:68). The Merlot peer reviewers gave this resource a rating of 5.0.

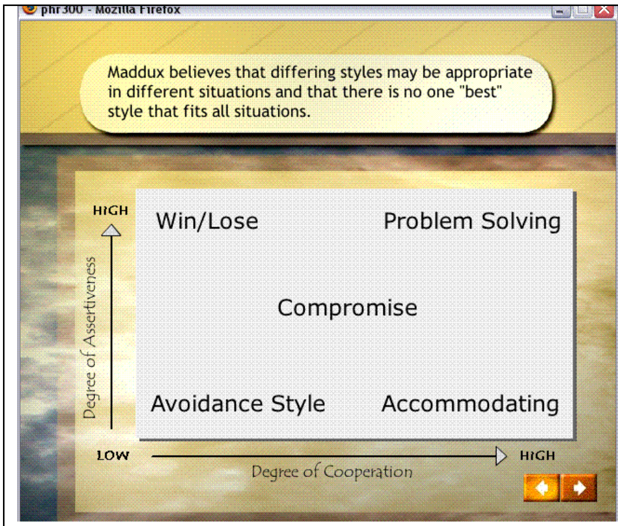

Figure 3: Screenshot of the Conflict Resolution Learning Object; Informational Component[10]

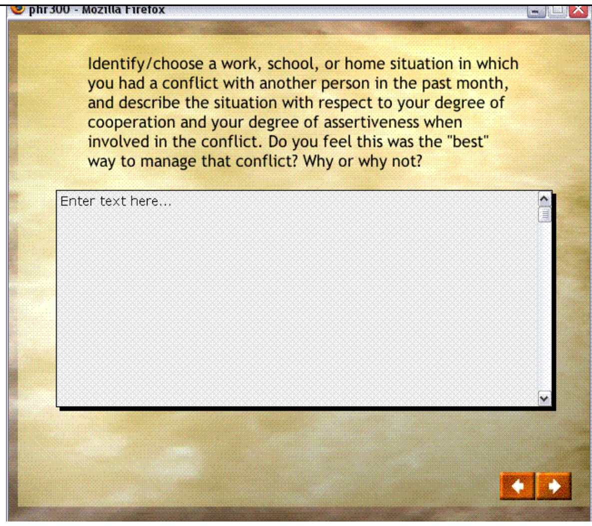

Figure 4: Screenshot of the Conflict Resolution Learning Object; Educational Component.

If there were complex objects that contained many links and resources, a sample was taken. However, entire courses were not evaluated. Generally, learning objects were placed into the

[9] Screenshot taken from „Comparative Anatomy" of The eSkeletons Project: http://www.eskeletons.org/
[10] The Conflict Resolution Style Learning Object was taken from: http://www.wisc-online.com/lrnobj/psycHR/PHR300/index.html

highest category, for which they fulfilled the corresponding criteria, since they include the levels below them.

4.2 Results of the Analysis

The number of viewed resources within Merlot was 204 (sample size), from which more than half received the highest overall rating within Merlot – 5.0. Of these 204, 50 objects (about 25%) could not be classified at all, neither as information objects nor as learning objects. Reasons for this include the repetition of objects within the list, non-connectivity of websites on the World Wide Web, sites were repositories or databases themselves, they were complete courses instead of rather granular objects, mere advertisements, project descriptions, or the resources received an overall rating less than 4.5.

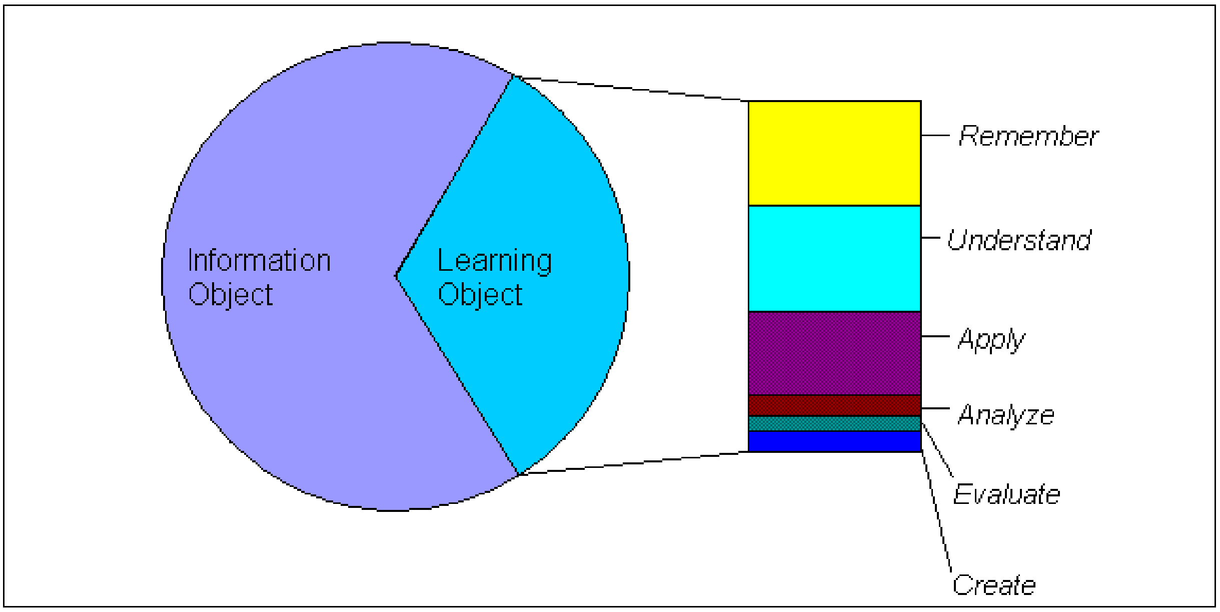

Figure 5: Distribution of Information Objects and Learning Objects, including the breakdown for Anderson & Krathwohl (2001) Categories.

The exclusion of some objects from the classification resulted in an overall usable sampling size of 154. From this sample, most resources (67 %) were classified as information objects since they lacked an obviously supported cognitive process. The number of information objects compared to the number of learning objects is portrayed in Figure 5, which also shows the breakdown of learning objects according to their respective Anderson & Krathwohl categories.

Looking just at the learning objects, a high focus appeared on the lower cognitive processes (Categories Remember, Understand and Apply). The number of learning objects placed in these categories represented 82%, while 18% of the viewed learning objects were categorized as higher cognitive processes (Categories Analyze, Evaluate, Create).

If all resources that were classified as information objects would hypothetically be considered learning objects of the category ‘Understand’ (for instance, students are able to explain a concept presented by the resource), the ratio of lower to higher categories would be even more in favor of the lower categories (95% vs. 5%, respectively).

Noticeable is that objects within Merlot that received a special status like “Editor’s Choice” and “Merlot Classics” were likely to present some type of supported cognitive process, meaning they were actually learning objects, not information objects. Along these thoughts it is also useful to mention that learning objects with a lower rating (less than 4.8) from the Merlot peer reviewers tended to be information objects, meaning they just presented subject matter without learning activities.

One side effect of looking at the resources in Merlot concerned reusability aspects. Most resources were too large, or too heavily embedded in their corresponding organizational websites. Often, it would not have been possible to assemble these objects into greater units of learning as suggested by the autodesk model (cp. Figure 1 on page 2) because they were not independently standing, meaning context-free.

5 Conclusion and Outlook

The analysis showed that current definitions of learning objects do not go far enough. To label learning objects as *learning* objects when all they do is present information signifies the widely used and at the same time for its vagueness frequently criticized definition, “any entity, digital or non-digital, that may be used for learning, education or training” (IEEE, 2002:6). A further distinction and clarification of the term “learning object” is necessary. This paper proposes a method to distinguish learning objects from information objects using a taxonomy of cognitive processes.

The analysis of learning objects within Merlot showed that two thirds of the resources could not explicitly support a cognitive process and were therefore labeled as information objects. Of the items that supported cognitive processes, the majority supported lower cognitive processes (82%). Therefore, it is being concluded that learning objects still focus too much on lower cognitive processes; higher processes are being neglected.

Including not just lower but also higher cognitive skills holds several advantages, among them the increased potential to address more than one type of learner and the improvement of assessment validity when testing across several categories (Nitko, 2004:27). Flechsig (1996:4f) states that including different methods during instruction, implying different levels within the taxonomy, serves a great variety of learning styles. This in turn improves teaching and learning processes.

Knolmayer & Montandon (2003:18) stated, though, that the development of learning objects that supported the higher cognitive processes required a much extended specification and implementation effort. This economic consideration along with the fact that we need mechanisms to enrich information objects in order to create true learning objects represents one research focus of the CampusContent project. If educational components like learning objectives and activities could not only be supplied but also be used as catalysts, a greater degree of information object assembly and reusability were possible.

The idea of CampusContent is to join information objects with educational components, such as learning objectives and activities, to create learning objects, but still keeping informational and educational parts as separate as possible (cp. Baumgartner & Kalz, 2005). One possible linking of educational components with information objects could be achieved using the taxonomy of Anderson & Krathwohl: the information objects receive a categorization in the knowledge dimension while the educational components are categorized in the cognitive process dimension. Automatically coupling these two parts enables us to switch the type of knowledge as well as the degree of cognitive process at the learner's demand. This creates potential for flexible learning paths.

Making not just information objects but also educational components reusable would enable users to save time since they do not have to reinvent activities over again for the information objects they wish to adopt. This is especially important, since activities for higher cognitive processes require more effort when being constructed as Knolmayer & Montandon (2003) stated. At the same time, since the educational components are stored separately from the information objects, the reusability of information objects remains the same – their potential to be reused in several contexts remains high. Therefore, our idea works towards a greater integration of pedagogical aspects into learning objects while preserving the high reusability of information objects. The project team CampusContent is working on further developing and implementing this approach, moving towards lesson and course construction.

6 Acknowledgements

The author thanks Sascha Bobrowski, Timo Borst, and Marc Jelitto for their comments on an earlier draft version of this paper. Furthermore, thanks are extended to professors Peter Baumgartner, Firoz Kaderali and Bernd Krämer for their helpful discussions and their support in the development of this paper.

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