A review of three textbooks for LCA have been published as Weidema B P, Brandão M. (2019): Book Review. Journal of Industrial Ecology. This file provides more detailed comments for one of the textbooks:

Detailed comments for the ILCA assessment criteria for a good beginner's LCA textbooks for Matthews H S, Hendrickson C T, Matthews D H. (2016): *Life Cycle Assessment: Quantitative Approaches for Decisions That Matter* – lcatextbook.com

By Bo P. Weidema & M. Brandão

General requirements

Low (or no) price
Free (Electronic version)

Up-to-date
Updated every 6 months.

Readability (Numerical score: Flesch–Kincaid test, using word length and sentence length, applied to textbook introduction)
49 (Fairly difficult).

All new topic-specific terms explained when introduced and/or in glossary
Carefully explains all terms introduced. However, does not contain an actual glossary.

Mentions alternative terms used in practice, to provide the student with an appropriate vocabulary to comprehend the general literature that use these alternative terms
Alternative terms used in practice are seldom mentioned (for example the alternative terms of "industry" instead of "sector", "activity" instead of "process", "exchange" instead of "flow" are not mentioned).

Does not introduce unnecessary terms or use terms in other ways than usual, unless clearly justified and announced
A few definitions may not correspond to general usage, such as reserving the term "recycling" for "material recycling", thus leaving us without an overall term to cover reuse, remanufacturing, material recycling and energy recovery.

Logical structure, avoiding repetition and avoiding introducing topics that later turn out to be unnecessary
The description of the inventory analysis takes its starting point in the steps of ISO 14044, interpreted as a bottom-up process flow diagram approach, slowly building up the product system from individual unit processes. This leads the authors to suggest that "If data is not available or inaccessible, then the product system, system boundary, or goal may need to be modified" … "For example, an initial system boundary may include a waste management phase, but months of effort could fail to find relevant disposition data for a specific product

of the process. In this case, the system boundary may need to be adjusted (made smaller)" Yet, the later Chapter 8 introduces the option of top-down LCA screenings starting from the more complete input-output databases, which makes cut-offs and system boundary modifications unnecessary. From a practical (and didactical) perspective, it may be helpful to start with the LCA screening (i.e. Chapter 8) and the use of matrix calculation for process-based LCA (Chapter 9), which would eliminate a lot of those issues of a bottom-up approach that may seem tricky (like the lack of data and consequent needs for cut-offs or system boundary modifications) or unexplained (like the ISO 14044 step of "Translating Data to the Functional Unit"). An initial introduction to the different ways that direct requirement IO matrices are produced from the original make-use IO matrices and the implicit assumption of markets – core issues which are unfortunately not included in the textbook's chapter 8 on IO calculus, dismissed (on p. 216) as "better left for the teacher or student to implement" (!?) – would also facilitate the later use of matrix notation to clarify the parallel issue of alternative procedures for handling co-production in LCA. Co-production is extensively treated in Chapter 6 of the textbook, but the initial emphasis is on allocation, which in the end is only recommended to be "used as a proxy in some specific cases". The clarity of this chapter could have been increased substantially by an initial elaboration on the core distinctions of average versus marginal modelling and combined versus joint production. The core distinctions of average versus marginal modelling (in the context of attributional and consequential modelling) is only introduced late in Chapter 6 – after the examples of system expansion – although this distinction really belongs to the goal and scope of an LCA (i.e. in Chapter 4).

Contextualizing LCA within its broader field
The first chapter is on life cycle thinking and introduces a brief history of environmental engineering.

Clear relationship to Life Cycle Costing and Life Cycle Sustainability Assessment
Sustainability assessment is briefly mentioned, but social impacts are not addressed. Already the third chapter introduces Life Cycle Costing (LCC) and discounting – a perspective that may be a bit unusual for LCA practitioners, but which provide a simple introduction to the calculus, without the need to consider all the physical complexity that are then introduced in later LCA chapters. The chapter also serves as an important reminder that in a decision context an LCA result always need to be combined with the LCC result in order to obtain a complete picture of the overall impacts.

Basic concepts are introduced
The first chapter introduces some basic concepts.

Introduces basic quantitative skills required
The second chapter introduces some basic quantitative skills "intended to build good habits in critically thinking about, assessing, and documenting your work in the field of LCA (or, for that matter, any type of systems analysis problem)."

Clear relation to ISO standards
From Chapter 4 onwards, the textbook follows the iso 14040-series of standards, covering the different phases of an LCA study, from the goal and scope phase (Chapter 4), over the inventory analysis (Chapter 5-9), to impact assessment (Chapter 10). The life cycle interpretation stage is covered already in relation to the inventory analysis (in Chapter 5) and no separate discussion is made on interpretation after the impact assessment (in Chapter 10).

Provides additional detail and explanations relative to ISO
The text provides additional detail, explanations, examples and references to relevant further reading. Structural Path Analysis (an important tool for interpretation) receives its own Chapter (Ch. 12).

Quantitative uncertainty and data quality clearly stressed throughout in an operational manner
Chapter 2 introduces uncertainty and in Chapter 5 a 20% rule of thumb for significance is suggested. Uncertainty is mentioned throughout the book, and separately discussed in Chapter 7.

Rigour and prudence throughout the text, and providing rationales for any normative statements
Rigour and prudence are prominent in the inventory chapters. However, in Chapter 10 (a simple introduction to Life Cycle Impact Assessment, again following the steps suggested in the ISO standards) there is no discussion of the implicit weighting that may occur when choosing and normalising impact categories.

Providing rationales and practicable procedures for all recommendations
Yes.

Text and calculations checked for errors
Through feedback from readers, errors are corrected on a 6-monthly schedule.

Real-life examples throughout, illustrating good practice and the points made in the text
Yes, lot of real-life examples that illustrate the points made.

Relevant and tested exercises provided
Each Chapter ends with exercises, which have been tested by a large number of teachers.

Additional resources provided for download
For the most crucial part of the textbook (on matrix calculation) there is a free game-like simulation that is highly recommended.

References to relevant further reading
Yes

Option for providing feedback to authors (and having responses)
Readers can suggest changes and communicate with the authors via the web-site, chapter-by-chapter.

Specific content requirements

Introduces setting of goal and scope, including the core distinctions of average versus marginal modelling
Goal and scope is described in Chapter 4, but marginal and average modelling is not introduced until late in Chapter 6 (on co-products).

Introduces the concept of a functional unit, including the conditions for substitution
Chapter 4 introduces the functional unit and reference is given to Weidema et al. (2004).

Introduces procedures to ensure all relevant impacts are included in an LCA study, including social issues
Not mentioned.

Basic introduction to unit processes and data collection for these
In Chapter 5.

Introduces the construction of linked databases from unit processes, introducing also the parallel between matrix and flow chart notations
Inventory analysis is described as a bottom-up process flow diagram approach, slowly building up the product system from individual unit processes. Matrix calculation is introduced quite late, in Chapter 9.

Basic introduction to the inventory calculus, explaining also the similarity of process LCA and Input-Output calculus
Introduced rather late (in chapter 9 on "Advanced Life Cycle Models").

Introduces the options for combining process-based and IO LCA, highlighting the options for taking the best from both approaches and avoiding cut-offs
Chapter 9 has a wonderfully clear explanation of the similarity of process LCA and Input-Output calculus, clarifying the way the matrix named A is used differently in the two "classical" notations (Matrix A represents the technology matrix in LCA lingo, while representing the Use matrix in IO lingo and since Technology matrix = Make matrix minus Use matrix, this explains the traditional LCA sign conventions for the Technology matrix). The remaining part of Chapter 9 is dedicated to the combination of process-based and IO LCA, highlighting the options for taking the best from both approaches.

Introduces the concepts of markets
Not introduced.

Introduces alternative procedures for handling of co-production, including the distinction between combined and joint production
Yes, in Chapter 6.

Introduces the concept and procedures for handling rebound effects
Not mentioned.

Introduces the relevance of temporality of emissions (e.g. the often erroneous assumption of neutrality of biogenic CO2-emissions)
Not mentioned. In an example in Chapter 6 on co-production, it is mentioned that the biogenic emissions of CO2 in a full life cycle may be considered to be neutral, "in lieu of crediting the natural product for this same uptake of carbon, which would lead to a net of zero emissions" (not in line with ISO 14067).

Introduces Life Cycle Impact Assessment and the impact pathways (cause-effect chain, environmental mechanism) concept
Yes, in Chapter 10 (however not quite with the rigour and prudence found in the inventory chapters; see above)

Explains the implicit weighting that may occur when choosing and normalising impact categories
Not mentioned.

Introduces the procedural aspects of weighting, objectivity-criteria, the role of science in soliciting values, and democratic and consensus-based approaches to weighting
Not mentioned.

Introduces mass balancing as quality assessment tool in both inventory and impact assessment
Introduces mass balancing as a quality assessment tool for inventory (in Chapter 4), but not for impact assessment.