

Technical University of Denmark



## Learning Objectives for Master's theses at DTU Management Engineering

Notes of inspiration to Master's students who have just started working on their Master's thesis, as prepared for the Study Board at DTU Management Engineering

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## **Learning Objectives for Master's theses at DTU Management Engineering**

Notes of inspiration to Master's students who have just started working on their Master's thesis, as prepared for the Study Board at DTU Management Engineering



Claus Thorp Hansen, Birgitte Rasmussen, Hector Nøhr Hinz

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## Introduction

Learning objectives are normally formulated when you participate in a DTU course. It is namely the teacher's task to formulate learning objectives and then evaluate your fulfilment of the learning objectives when assessing you exam or replacement assignment.

With Master's theses it is, however, different. The DTU Study Handbook states that: "Learning objectives are an integrated part of the supervision", which provides you with the opportunity – naturally in cooperation with your supervisor – to formulate learning objectives for your Master's thesis.

There are at least three good reasons for being thorough when formulating learning objectives for your Master's thesis. Firstly, the learning objectives will help you find a prudent approach to be used in your Master's thesis. Secondly, the learning objectives will help describe the basis on which you are assessed when the report has been submitted and you present and defend your Master's thesis. Thirdly, the learning objectives constitute a way of describing what you have learned and acquired of knowledge, and it is important to bear this in mind when you apply for a job as newly qualified Master of Science in Engineering.

It is also important that you formulate precise and useful learning objectives for your Master's thesis. These notes of inspiration have been written to help you do exactly this. The notes discuss the requirements for the learning objectives, examples of learning objectives and the assessment criteria defined by DTU Management Engineering as well as, but not least, some useful things to remember concerning your submission and the assessment of the Master's thesis.

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8. Other project-relevant assessment criteria
  - How well has the task been solved.
  - How good, solid and/or comprehensive is the synthesised technical or socio-technical solution.
  - Whether the student has included all relevant criteria in the evaluation of the solution.
  - How original the solution is.
  - How good the documentation is for the external partner.
  - How professional the handover of the project results to the external partner is planned and/or carried out.

[DTU Management Engineering, letter to examiners (in Danish), 2009]

### Annex 3. Assessment criteria – for examiners

For the assessment of Master's theses at DTU Management Engineering, please use both the overall objectives and objective achievement criteria formulated in the Master's thesis report, and the 7 general assessment criteria. A top achievement, a medium achievement, and an achievement for passing has been formulated for the 7 general criteria (alternatively: an upper level, a medium level, and a level for the just acceptable). The formulations are meant as a guide to the evaluation of a student's overall achievement, and you should not determine a grade for each individual criterion. Also, all criteria do not necessarily carry the exact same weight.

The three achievement levels are:

- a) Top achievement:
  - Knowledge: Solid knowledge, insight and overview.
  - Application: Solid exposition, independent application and critical reflection
- b) Medium achievement:
  - Knowledge: Some knowledge and insight
  - Application: Clear exposition and relative consistent application
- c) Achievement for passing:
  - Knowledge: Sufficient, but limited knowledge
  - Application: Sufficient exposition and application

#### The 7 general assessment criteria:

1. Knowledge of the chosen subject matter
2. The relevance of the problem for the chosen discipline
3. The relevance of theories and methods in relation to the problem
4. The application of theories and methods
5. Collection and application of empirical data or other documentation
6. Analysis, creation of results, conclusion and putting the work into perspective
7. Structuring and presentation (report, oral presentation and defence)

The above-mentioned 7 general assessment criteria focus on what the student learns through a Master's thesis. However, a Master's thesis should also be assessed based on the formulated project objectives, and the below list is included for inspiration and shows examples of project-relevant assessment criteria.

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## 1. You must formulate learning objectives for your Master's thesis

The policy of DTU is to not formulate learning objectives for Master's theses centrally. The reason for this is that many Master's theses are so different that a set of centrally defined learning objectives will be pointless to apply in practice. Focusing on the types of Master's theses that are offered by DTU Management Engineering, it is also possible to find a wide range of projects:

- Mathematics/natural science, technology/engineering science, socio-technology/social sciences.
- Analysis, synthesis, method and research projects.
- Without or with collaboration partner/external partner (e.g. a company, public institution or interest group).

Hence, there are various types of Master's theses at DTU Management Engineering. The study board has therefore decided not to define a set of learning objectives for all the types of Master's theses. So it is your task to formulate a set of learning objectives for your Master's thesis in cooperation with your supervisor.

## 2. The objectives and stakeholders of a Master's thesis

Under all circumstance, a Master's thesis entails *two objectives* which you should have a clear idea about before formulating the learning objectives. One thing is the actual *academic* requirements: To solve the academic problem in the best possible way. The other is the *documentation objective*: That the Master's thesis at the completion of your Master's programme documents that you are now a university graduate. This last thing means that your Master's thesis should comply with the accepted academic standards with regard to e.g. literature search, description of theory, conduction of tests and experiments as well as the reporting of results.

With regard to objectives for your Master's thesis, you should first of all note that there can be many different ones:

- It can be *learning objectives* describing what you would like to be able to after having completed the project.

*Analyse, appraise, arrange, break down, calculate, categorise, classify, compare, connect, contrast, criticise, debate, deduce, determine, differentiate, discriminate, distinguish, divide, examine, experiment, identify, illustrate, infer, inspect, investigate, order, outline, point out, question, relate, separate, sub-divide, test.*

### Synthesis

Synthesis can, in the sense used in Bloom's taxonomy, be defined as the ability to put parts together. Some of the active verbs used to assess synthesis are as follows:

*Argue, arrange, assemble, categorise, collect, combine, compile, compose, construct, create, design, develop, devise, establish, explain, formulate, generalise, generate, integrate, invent, make, manage, modify, organise, originate, plan, prepare, propose, rearrange, reconstruct, relate, reorganise, revise, rewrite, set up, summarise.*

### Evaluation

Evaluation can, in the sense used in Bloom's taxonomy, be defined as the ability to judge the value of material for a given purpose. Some of the active verbs used to assess evaluation are as follows:

*Appraise, ascertain, argue, assess, attach, choose, compare, conclude, contrast, convince, criticise, decide, defend, discriminate, explain, evaluate, grade, interpret, judge, justify, measure, predict, rate, recommend, relate, resolve.*

[The DTU Portal, Infosite for teachers]

## Annex 2. List of active verbs

The below list contains various active verbs that are often used in connection with the description of learning objectives. The verbs are related to a modified version of Bloom's taxonomy and are meant as a guide – other verbs can be used.

### Knowledge

*Knowledge* can, in the sense used in Bloom's taxonomy, be defined as the ability to recall or remember facts without necessarily understanding them. Some of the active verbs used to assess knowledge are as follows:  
*Arrange, collect, define, describe, duplicate, enumerate, examine, find, identify, label, list, memorise, name, order, outline, present, quote, recall, recognise, recollect, record, recount, relate, repeat, reproduce, show, state, tabulate, tell.*

### Comprehension

*Comprehension* can, in the sense used in Bloom's taxonomy, be defined as the ability to understand and interpret learned information. Some of the active verbs used to assess comprehension are as follows:  
*Associate, change, clarify, classify, construct, contrast, convert, decode, defend, describe, differentiate, discriminate, discuss, distinguish, estimate, explain, express, extend, generalise, identify, illustrate, indicate, infer, interpret, locate, paraphrase, predict, recognise, report, restate, rewrite, review, select, solve, translate.*

### Application

*Application* can, in the sense used in Bloom's taxonomy, be defined as the ability to use learned material in new situations, e.g. put ideas and concepts to work in problem solving. Some of the active verbs used to assess application are as follows:  
*Apply, assess, calculate, change, choose, complete, compute, construct, demonstrate, develop, discover, dramatise, employ, examine, experiment, find, illustrate, interpret, manipulate, modify, operate, organise, practice, predict, prepare, produce, relate, schedule, select, show, sketch, solve, transfer, use.*

### Analysis

*Analysis* can, in the sense used in Bloom's taxonomy, be defined as the ability to break down information into its components. Some of the active verbs used to assess analysis are as follows:

- It can be *result objectives* describing the type of solution you are aiming at in the project and how good it should be as well as describing how far you would like to get in the creation of results, e.g. a concept, a prototype, a detail level or full implementation.
- It can be *process objectives* describing how you will approach the task, which methods you will use and which actors you will include and in what way.
- It can be *presentation and communications objectives* describing how you will communicate partial results and results, as you go along and at the end of the project, to the examiner, supervisor, external partner, and other stakeholders.

Secondly, you should be aware that the relative importance of the various objectives is not the same for the various project stakeholders:

- For *you* as a Master's thesis student the overall success criterion will be to carry out an exciting and educational project.
- For an *external partner/collaboration partner* (i.e. the person or organisation who comes forward with the assignment or problem), the success criterion will be found in the adequacy and realisability of the technical or socio-technical solution you create.
- Your *supervisor* will often have a big interest in the solution. If you have an external partner/collaboration partner, *the supervisor* will sometimes primarily be a process supervisor, in which case the supervisor's success criterion will be that you complete your project through qualified engineering work and is graded fairly.
- For the *examiner*, your project is a way to stay updated academically and keep in good contact with DTU. The examiner's assessment of your project is both based on your ability to demonstrate qualified engineering work as well as to be able to solve the task.



As can be seen from the above, a Master's thesis has many kinds of goals, objectives and various stakeholders. You should therefore be careful when specifically detailing the objective formulation of the Master's thesis. Here the learning objectives play a particularly important role in terms of success. Therefore, it is not sufficient to simply solve the task, it should also be done using a qualified engineering

and academic approach; and the learning objectives can be a help in focussing on exactly this.

### 3. What are good learning objectives?

When you study and work with a subject, you gradually learn increasingly more about it; you become more competent, which in academic terminology is called progression in learning. The following is an example of progression in learning: If you step outside on a Winter's night with no clouds in the sky and look up, you will see a starry sky. You might get fascinated by the sight, and would want to learn more. So you start reading, buy a good telescope and observe the night sky often. You find out that there are many different objects in the sky (e.g. stars, planets and meteors). You understand the differences of the objects (e.g. that stars shine, planets are illuminated, and meteors emit light when they burn up on their way to the Earth), and their relative positions as controlled by the force of gravity. You use your understanding for systematic observations, and you gradually become a decent amateur astronomer, and you might be skilled and lucky enough to one night discover a as-yet undescribed object.

#### Correct formulation of learning objectives

At a university there is of course a need to be able to express the progression in learning throughout the study programmes. At DTU, it has been decided to use a modified version of Bloom's taxonomy, and figure 1 shows Bloom's hierarchy for learning concepts with, on one side, progression of learning and, on the other side, the corresponding complexity of the learning objective.

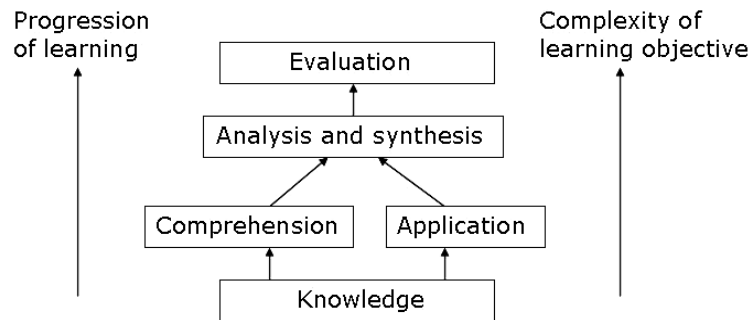


Figure 1. Bloom's hierarchy for learning concepts. [modified from the DTU Portal, Infosite for teachers]

- To express what a student must be able to have *knowledge* of a subject, the following active verbs can be used: *Arrange, collect, define, describe, duplicate, enumerate, ...*
- To express what a student must be able to do regarding the *application*, the following active verbs can be used: *Apply, assess, calculate, change, choose, complete, ...*
- To express what a student must be able to do regarding the *evaluation*, the following active verbs can be used: *Appraise, ascertain, argue, assess, attach, choose, ...*

Let's have a look at some examples of learning objectives. For course 41502 Strength of Materials 2, we find that:

A student who has met the objectives of the course will be able to:

- *Describe* the mechanical properties of time independent materials subjected to static, uniaxial tensile load.
- *Calculate* principal stresses and strains and their corresponding principal angles.
- *Design* with respect to fatigue failure ("infinite" life), including *make a reduced* Haigh diagram and *calculate* a fatigue safety factor.

[DTU Course Catalogue, 41502 Strength of Materials 2, excerpt]

Please note that the first learning objective concerns *knowledge*, while the two other learning objectives concern *application*.

For course 42628 Conceptualisation, we find that:

A student who has met the objectives of the course will be able to:

- *Create* comprehensive and integrated solutions.
- *Evaluate* conceptual vulnerability (attractiveness and tractability).
- Dynamically *adjust* staging in relation to current project status and obtained results.

[DTU Course Catalogue, 42628 Conceptualisation, excerpt]

Please note that the first learning objective concerns *synthesis*, while the two other learning objectives concern *evaluation*.

In annex 2, you will find a comprehensive list of active verbs for all six learning concepts which should be able to help you achieve an ambitious and correct formulation of learning objectives.

# Annexes

## Annex 1. Bloom's taxonomy

At DTU, it has been decided to use a modified version of Bloom's taxonomy, and figure 1 shows Bloom's hierarchy for learning concepts with, on one side, progression of learning and, on the other side, the corresponding complexity of the learning objective.

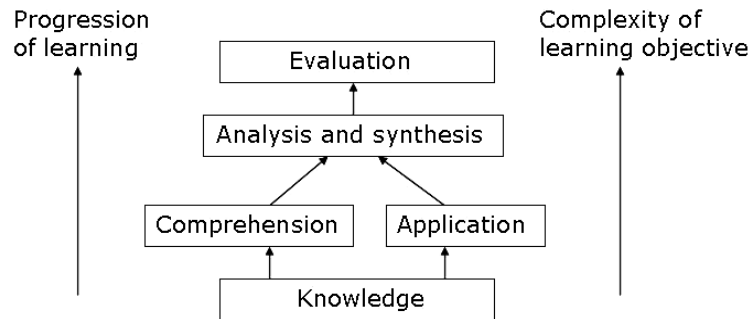


Figure 1. Bloom's hierarchy for learning concepts. [modified from the DTU Portal, Infosite for teachers]

At the DTU Portal, Infosite for teachers, you find the following definitions of the learning concepts that are shown in figure 1:

- *Knowledge* is the ability to recall or remember facts without necessarily understanding them.
- *Comprehension* is the ability to understand and interpret learned information.
- *Application* is the ability to use learned material in new situations, e.g. put ideas and concepts to work in problem solving.
- *Analysis* is the ability to break down information into its components.
- *Synthesis* is the ability to put parts together.
- *Evaluation* is the ability to judge the value of material for a given purpose.

For each learning concept a number of active verbs have been indicated and can be used to describe what a student is expected to be able to, to master the learning level.

Bloom's hierarchy defines a set of learning concepts: *Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation*. This is illustrated in figure 1. For each learning concept a number of active verbs have been indicated and can be used to describe what a student is expected to be able to in order to master the learning level. Here are two examples:

- To express what a student must be able to master to have *knowledge* of a subject, the following active verbs can be used: *Arrange, collect, define, describe, duplicate, enumerate, ...*
- To express what a student must be able to do to *evaluate*, the following active verbs can be used: *Appraise, ascertain, argue, assess, attach, choose, ...*

In annex 1 Bloom's taxonomy, you find definitions of the learning concepts as well as examples of formulations of learning objectives at the various levels. In annex 2, you find a list of active verbs that can help you formulate learning objectives for your Master's thesis.

### Content and number of learning objectives

The learning objectives for your Master's thesis must describe what you learn through the Master's thesis. Hence, they must describe how you identify and delineate your assignment, how you approach the solution and completion of the assignment, what result you arrive at, and how you evaluate the result. Therefore, the learning objectives must also include both a process and result dimension.

For the learning objectives to be of help to you in connection with your Master's thesis and be used in connection with the assessment, the learning objectives must comply with the following four criteria:

- I) Operational: They must help you articulate the learning dimension of the Master's thesis.
- II) Unambiguous and precise: They must not cause confusion and disagreement between you and your supervisor about the basis for the assessment.
- III) Measureable: Supervisor and examiner must be able to assess your Master's thesis on the basis of the formulated learning objectives.
- IV) Adequate and relevant: They must measure "everything" and "the right things".



When you formulate learning objectives, it is worth knowing that – for a DTU course – the following apply, which is what we also recommend for a Master's thesis:

- 8-12 learning objectives should be formulated.
- There must be no more than two active verbs for each learning objective.
- A learning objective must consist of no more than 250 characters.

In conclusion, it must be mentioned that when you formulate a set of learning objectives for your Master's thesis, you should be careful to make sure that the formulation is ambitious and correct, includes both the process and result dimension, complies with the four criteria, I) – IV), and falls within the DTU framework for the courses' learning objectives. Then you will already be well under way with your Master's thesis.

#### 4. Examples of learning objectives

In this section, you find two examples of learning objectives for Master's theses for inspiration.

**A Master's thesis at DTU Management Engineering** could include a framework of the following set of learning objectives:

1. Identify your own problem/project formulation.
2. Pursue and answer your problem in the report.
3. Find and describe the relevant literature within the scope of the problem.
4. Argument in favour of the choice of theory and method.
5. Use the theory and method in relation to the problem.
6. Be critical in relation to the theory and method.
7. Discuss, conclude on and put the results into perspective in relation to the theory and empirical data.
8. Report the obtained results structuredly, comprehensively, briefly, clearly, in a critically evaluating/concluding way, and of course also in accordance with good practice for a written presentation within the discipline (e.g. so that experiments can be repeated by others).
9. Answer the specific problem of the Master's thesis (in your own words): ...

assessment, but it is at the same time not sufficient to be able to read all details in a very long report carefully.

The above conditions often appear in connection with Master's theses, however they do not constitute an exhaustive list. Therefore, you also have to get to know the general rules for Master's theses. You find these rules in the DTU's Study Handbook at the homepage.

#### 6. Closing remark

We hope that this note of inspiration can help you get started with the formulation of the learning objectives for your Master's thesis. When you have written a first draft of the learning objectives, it is of course important that you discuss the draft with your supervisor, so that you will end up with a set of good learning objectives.



However, a set of good learning objectives is not enough for the Master's thesis to become a success, and for you to achieve a high grade. Therefore, we will end by encouraging you to also be thorough with the project planning and with the writing of the report.

All the best with your Master's thesis!

report, with an account of what you have learned from the Master's thesis.

- The examiner and supervisor will, among other things, assess your Master's thesis based on the overall objectives and objective achievement criteria as formulated for the project. Even though you have been thorough when formulating the learning objectives, some of the formulations may e.g. turn out to be ambiguous at the examination, or the total set of learning objectives may not be complete. The Study Board at DTU Management Engineering has prepared various general assessment criteria which examiner and supervisor will often use together with the learning objectives in the assessment of your Master's thesis. The general assessment criteria are included in annex 3.
- A Master's thesis should include an abstract in Danish and English.
- In accordance with the Danish Ministerial Order governing examinations at the universities (Ministerial Order no. 867 of 19/08/2004) each examination must consist of an individual assessment of the student's achievement. If you complete your Master's thesis on your own, there is of course no doubt about what your achievement is. If you complete your Master's thesis with a fellow student, both of you should take the individual assessment into consideration. An individual assessment of a two-student project can take place in two ways:
  1. You submit your common report and make an oral presentation. After the presentation, an individual oral examination is carried out.
  2. In the report, you state who have contributed with what. You can either describe who are responsible for which sections or pages, or you can also describe what you have each contributed with, e.g. with regard to data collection, experimental work, information search, model creation, programming, analysis, editorial work, etc. If you choose way 2, you can present and defend the thesis together.
- DTU pays examiner for 5 hours and 10 minutes per student for the assessment of a Master's thesis. Within that time frame, examiner will have to read and assess the report, listen to the oral presentation, ask questions during the defence and deliberate with the supervisor. Therefore, the examiner has an estimated 3.5 hours for reading and assessing a one-student report, and approx. 8 hours for a two-student report. This is entirely sufficient to provide a qualified and correct



Please note, that this set of learning objectives illustrates a qualified academic approach to the way of completing a Master's thesis. Based on this set of learning objectives, the supervisor and examiner assess the academic level throughout the project from the identification of the problem, through the choice and application of theory and method to the achievement of results and finally a critical evaluation of the results.

Furthermore, notice that the focus is on argumentation and reflection throughout the entire Master's thesis. All in all, a set of ambitiously formulated learning objectives.

The formulation of the cited set of learning objectives is so general that it could be applied in many Master's theses at DTU Management Engineering. Unfortunately, the formulation is so general that the learning objectives may not be providing sufficient help in each individual Master's thesis. However, you can use the formulations as the basis and inspiration for the formulation of the learning objectives for your own Master's thesis. Below, you'll find an example of learning objectives for a Master's thesis within concept development.

**Concept development:** In a Master's thesis aimed at developing new product concepts for a company, the following set of learning objectives would be an option:

1. Collect and evaluate data in connection with need and market analyses.
2. Analyse and systematise existing solutions.
3. Interpret results of need-, market-, business- and technology analyses and formulate an overall objective for the task.
4. Create ideas and concept suggestions.
5. Create a total solution space with the combination of systematic and creative techniques.
6. Create comprehensive and integrated solutions.
7. Evaluate the potential and realisability of solution concepts.
8. Prepare a decision basis for concept selection with potential, realisability and other relevant criteria in mind.
9. Stage the project based on an estimation of the scope, complexity and desired result of the task.
10. Dynamically adjust staging in relation to current project status and obtained results.

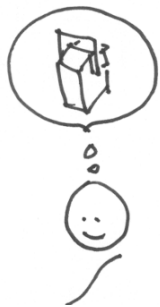
Please note that this set of learning objectives comprises a process dimension as well as a result dimension.

Process:

- The first three learning objectives focus on a research phase.
- The next three learning objectives focus on a concept creation phase.
- Learning objectives 7 and 8 focus on an evaluation phase.
- The last two learning objectives focus on the staging of the Master's thesis.

Result:

- Learning objective 3 deals with the *evaluation* of the information collected in the research phase and the formulation of an overall objective.
- Learning objective 5 and 6 deal with the *synthesis* of the entire solution framework and comprehensive and integrated solutions.
- Learning objective 7 and 8 deal with the *evaluation* of the synthesised comprehensive and integrated solutions.
- Learning objective 9 and 10 deal with the *evaluation* of the status of the Master's thesis (progress and the obtained results) compared to the formulated plan.



Please note that the learning objectives are ambitious in the sense that they are formulated in the upper levels of Bloom's hierarchy (figure 1) evaluation, analysis and synthesis.

A concept development will typically have an external partner, e.g. an industrial enterprise or an interest group, and a possible example of an external partner project objective could be:

- The overview of the total solution space (learning objective 5).
- The adequacy and realisability of the synthesised solution (learning objective 7 and 8).

You should be aware that if you keep in close contact with your external partner, e.g. because you have a desk at the external partner's premises, then there is a risk that the few result-oriented project objectives will occupy most of your mind. This will make you forget the entire

comprehensive set of project objectives on which the Master's thesis is assessed by the examiner and supervisor.

When you formulate learning objectives for your Master's thesis, you can use these two examples as inspiration, however, you can also get help from a couple of other places:

1. For each Master's programme a competency description has been prepared which you will find at DTU's homepage under Master's programmes. It is important that you study the competency description for your Master's programme so that the learning objectives for your Master's thesis are in line with the competency description for the Master's programme.
2. It is a good idea to look at the learning objectives for the course(s) that your Master's thesis builds on.

## 5. Assessment of Master's theses

When the time comes for the examiner and supervisor to assess your Master's thesis, there are some points that are worth keeping in mind. These points are mentioned briefly here, so that you can consider them already from the onset:

- The basis for the assessment of a Master's thesis is the report that is submitted, the oral presentation and the defence in the presence of the examiner and supervisor. The report that is submitted forms the primary basis of the assessment, however, it is not unusual that a convincing presentation and a good defence can increase the grade. It is also important that you prepare yourself properly for the oral part of the submission.
- When, during the project work, you use time and put in an effort to formulate good learning objectives under supervision, you should make sure that the examiner is aware of the formulated learning objectives and take them into consideration as part of the assessment. This can e.g. be done by describing and explaining the learning objectives in the chapter with the introduction of the report as well as by including a section in continuation of the conclusion of the

