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Can student's learning outcome be improved by modified guided inquiry learning?

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Introduction

University teaching has evolved during the last decade to actively include students in courses using approaches such as theoretical exercises, laboratory exercises, quizzes and dialog among teacher and students. There is however still challenges that needs to be addressed in the current educational system. At University of Copenhagen, three hour blocks of lectures are currently not uncommon and if the lecturer is a guest and not the course responsible it may not be feasible to develop laboratory or theoretical exercises to activate students. Student activation is an important method to maintain student attention throughout the lecture (Bunce et al. 2010) and furthermore studies show increased understanding and learning outcome when active learning approaches are implemented as supplements to lectures (Brown 2010, Freeman et al. 2014). If the short attention span of students is ignored and traditional lecture format is continued students learning may be compromised.

According to the Structure of Observed Learning Outcome (SOLO) taxonomy of learning, students learning can be evaluated by 5 groups/steps of learning outcomes (Mørcke & Rump 2013). SOLO steps 4 and 5 summarizes the deep learning process where students learn to analyze, interpret, use (step 4) and develop new hypotheses and perspectives (step 5) from the learned topic. In the following, skills obtained in SOLO steps 4 and 5 are designated as higher level thinking skills. In this project the objective was to increase students understanding and deep learning by including disruptive elements in the lectures in the form exercises inspired by a semi-inductive

approach and guided inquiry learning. These exercises will in the following be represented by the term modified guided inquiry learning (MGIL). Inspiration and the scientific validity of guided inquiry learning is found in results produced at Washington University in St. Louis, MO, USA where courses in science, technology, engineering and mathematics (STEM) have been successfully improved by process-oriented guided inquiry learning (POGIL) (Eberlein et al. 2008). he aim is to facilitate deep learning among students as they work through small exercises of which the theoretical background is unknown. Through discussion with peers, students will reflect on the issues presented and hopefully this way form new elements of knowledge to construct additional knowledge from.

Problem statement

Activation of students is critical to obtain efficient knowledge transfer during lectures. Especially guest teachers may benefit from the use of short and informative exercises in a format using modified guided inquiry learning (MGIL). But how do the students react to this approach? This is not known. In the current project the following questions will be answered:

Q1: Do students understand key points conveyed by MGIL 6 months after the session?

Q2: Do students feel that MGIL benefit their learning?

Q3: What are the challenges when using MGIL in lectures from the students' perspective?

Background

MGIL was applied in the bachelor course Plantevidenskab at University of Copenhagen. Students attend the course on their 3rd year as part of the BSc program Natural Resources. Course topics are breeding, growth, production and quality of plants. The course is placed in block 2 in timetable groups B and C and yields 15 ECTS points. Students follow lectures and simultaneously work on selected research projects in groups. The exam form is multiple choice questions covering lectures and the deliveries and

defense of a project report. Two 3 hour lectures were designed to include MGIL exercises at 15-20 minute intervals to disrupt the monotonous nature of the traditional lecture. In lecture 1: Kvalitet og kontrol af ethylens virkemåde, 10 of the 16 enrolled students attended. In lecture 2: Bioteknologiske metoder i produktudviklingen af højværdiafgrøder, 11 of the 16 enrolled students participated. The learning objectives for lecture 1 and 2 are presented in Danish in Figure 17.1.

Results and discussion

Students of Plantevidenskab received a questionnaire 6 months after course completion (Appendix A). The questionnaire contained basic questions related to lecture 1, lecture 2 and to how students perceived the two lectures. Of 16 possible students, 7 students which attended the lectures replied – yielding a response of 64%.

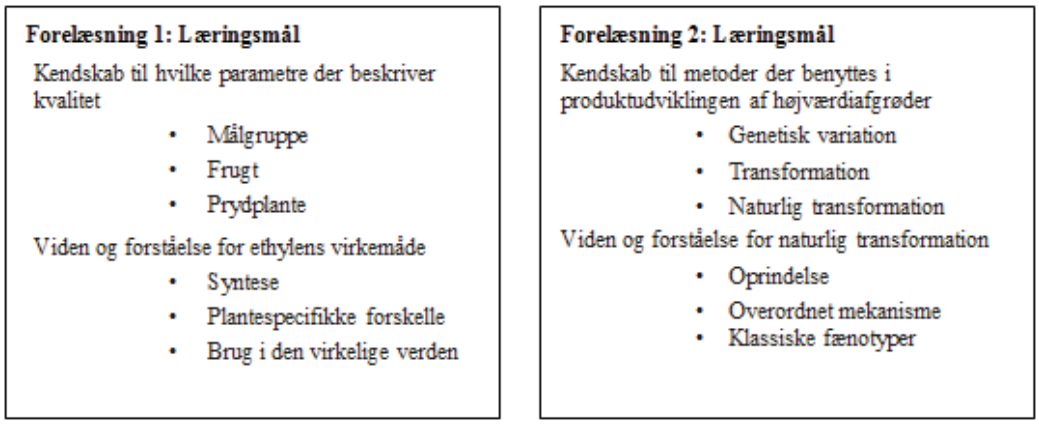

Fig. 17.1. Learning objectives in lecture 1 (Kvalitet og kontrol af ethylens virkemåde) and 2 (Bioteknologiske metoder i produktudviklingen af højværdiafgrøder) in the bachelor course Plantevidenskab. Objectives are in Danish as the course is running in Danish.

Students understanding and recall of knowledge conveyed to them in lectures 1 and 2 were surprisingly good. Even though the questions are simple and easier than exam questions on the same topic a person with no prior knowledge would not be able to answer. In some replies students commented... "Ja, det mener jeg?".. or .."husker ikke".. or .."ved ikke"... This indicate that they followed guidelines as directed in Appendix A and did

not cheat by searching online for answers. Actually a student commented ...“ Jeg husker forbløffende meget (ved jo ikke om jeg husker rigtigt :))”... As to the point raised in Q1, if students’ still understand key points of the lectures 6 months later – they do, at least 64 % of them. However if MGIL is responsible for this cannot be determined in this context. Uncharacterized factors may influence the result such as personal interest in the topics or the close relation of the topics to the students’ everyday life (as the features discussed address flowers and fruits).

The MGIL exercises were well received by the students. On the day of the lecture they found the exercises strange (my view) due to the low amount of prior knowledge given to them beforehand. However, when asked 6 months later many of them were positive to the approach using exercises first and the theoretical part covering the exercise afterwards. When asked if they liked the use of exercises before lectures student remarks were ...“Både og; det skærper nysgerrigheden for at få svar på de spørgsmål man nu ikke kunne svare før forelæsningen, men samtidig er det godt at opsummere og afslutte forelæsningen med øvelser”... “Ja – Men kun hvis det bliver brugt aktivt som appetitvækker. – Noget som vækker appetitten. Det kan også blive for elementært når det netop er før oplægget”... “Generelt virker det godt at have øvelser inden forelæsning. Dette kan være med til at sætte fokus på hvad der er vigtigt i forelæsningen, og viser hvad teorien kan bruges til”... “Jeg tror at indlæring øges når man stimuleres til at tænke selv”... in contrast a student found it .. “ret irriterende”... None of the students believed the order of exercises versus lectures had any effect on their learning and therefore also did not identify any connection between MGIL and improved learning (answer to Q2). However all students found the presence of exercises pivotal to their ability to acquire new knowledge. Representative comments to the importance of exercises on their ability to learn were... “Øvelser er meget nødvendige”... “det er svært bare at huske en talestrøm”... “ Ja!! (øvelser er vigtige)”... “Det er alfa omega. – og for mig forskellen på at kunne nogle facts, og sætte dem ind i en sammenhæng”... Considering student experiences exercises should always be included in lectures in some format. Depending on the topic, time span and if the lecture is a returning event, teachers have multiple options. If focus is on the guest lecturer which teaches once or twice a year, there is a need for exercises in a format that is cheap, do not need laboratory equipment and can be completed during the available timeslot. MGIL exercises could be good candidates for this.

Students from Plantevidenskab identified some shortcomings in the used format of MGIL (Q3). Exercises where in some cases too simple... "Nogle af dine øvelser var måske lidt for nemme - måske netop fordi de kom før teorien"... "Det kan også blive for elementært når det netop er før oplægget"... As a rule easier exercises where placed in the beginning of lectures, they were used to warm up the students and to facilitate a gentle introduction. The more difficult exercises were placed later in the lecture; students may have forgotten these 6 months later. Examples of easy and difficult exercises are presented in Appendices B and C, respectively. As this was the first year MGIL was introduced to Plantevidenskab it was challenging to estimate the students prior knowledge especially with regard to their knowledge on basic plant physiology and molecular techniques used in plant sciences. These topics can with benefit be more integrated in the exercises applied in the course during winter 2015 thus accommodating students' wishes.

One of the limitations of the study is the low response rate of 64 %. If the responding students represent the full group or if only students knowing the answers replied is not known. Also, students were asked to answer questions without the use of notes, the internet, but if they followed this instruction cannot be determined in the current layout. Additionally monitoring student learning in a control lecture not using MGIL, but using the same group of students could have been informative, however this was not possible to include in Plantevidenskab in the 2014/2015 period.

Conclusions

MGIL exercises were successfully implemented in the bachelor course Plantevidenskab at University of Copenhagen. The purpose of exercises was to keep students engaged in lectures spanning 3 hours including pauses. Also exercises were applied to help student's learning and understanding of the theoretical material. On lecture days student and teacher interactions were frequent and the learning environment was active and engaging. 6 months after the course the recollection of the basic points of lectures were well preserved. Students could remember effects of ethylene on plants and basic ethylene biology (lecture 1) and principles from biotechnological methods described in lecture 2. Students were positive towards MGIL exercises 6 months after the lectures but were sceptic as to the effect of these exercises on their learning. They all however stressed that exercises

in general had a positive effect on their learning. In retro perspective MGIL exercises can be expanded in the next course period to include more challenging material and to stretch over longer periods. This may be possible in the next course period due to more time in the planning phase and a better understanding of student's prior knowledge when starting the course Plantevidenskab.

Perspectives

MGIL exercises are a fusion of semi-inductive exercises where all new knowledge generated are developed from the students and POGIL exercises which take place in highly structured student groups with teacher assistance. In POGIL the key point is that students help each other to realize new principles and ways of thinking. Common for both types of exercises is that students themselves realize how biological problems arise, can be solved and which components are necessary in this process. In such cases there is a higher chance of long-term retention of knowledge. The utility of POGIL exercises is well documented. In a pharmaceutical course higher level thinking skills were improved when student's exercises were designed to fit the POGIL strategy (Soltis et al. 2015). Low level thinking skills were unchanged but for exam questions requiring higher level thinking increased performance of students exposed to POGIL was found. In higher level thinking questions students are required to analyze and apply their knowledge as described by SOLO taxonomy. Also significant increases in student grades attending medicinal chemistry with included POGIL exercises have been reported (Brown 2010).

A Questionnaire

Kære tidligere studerende ved temakurset Plantevidenskab

Jeg havde fornøjelsen at undervise jer i efteråret i to forelæsningssessioner under temaet højværdiafgrøder:

A: Kvalitet og kontrol af ethylens virkemåde
B: Bioteknologiske metoder i produktudviklingen af højværdiafgrøder

Jeg er ved at afslutte kurset Universitetspædagogikum, et kursus der bruges til uddannelse af kompetente undervisere på KU. I denne sammenhæng vil jeg bede jer svare på nedenstående spørgsmål. Jeg kan bruge jeres svar som feedback på den udførte undervisning og til at lave forbedringer for de kommende studerende på samme og på andre kurser hvor jeg skal undervise. I får til gengæld mulighed for at præge hvilken undervisningsform jeg vil bruge i fremtiden.

Jeg er tilfreds med korte svar – ja, nej, ved ikke er fint. Uddybelse er velkommen hvis I har lyst til dette ved nogle spørgsmål. Det er ikke min mening at I skal google eller kigge på gamle tekster for at svare, et ligefremt svar efter kort refleksion er perfekt. Jeg er interesseret i hvad I husker på nuværende tispunkt og hvordan I oplevede forelæsningerne dengang. Alle må gerne svare også de af jer der ikke deltog i den enkelte forelæsning.

I kan svare i det vedlagte Word dokument (gem og send den nye version) eller skrive direkte i teksten nedenfor og derefter svare på mailen. Jeres svar vil blive behandlet fortroligt og vil ikke blive sammenkædet med den enkelte studerende på noget tidspunkt. Jeg skal kun bruge data givet af jer som gruppe.

Spørgsmålene kommer her nedenfor. På forhånd tak, Josefine

Spørgsmål der refererer til forelæsning A (kvalitet, ethylen):

Er ethylen et næringsstof?
Er ethylen et plantehormon?
Er ethylen en væske?
Ordet klimakterisk referer til hvordan planten responderer på ethylen un-

der modning eller blomstring. Er en klimakterisk plante følsom overfor ethylen?
Øges holbarheden af frugt og blomster ved tilførsel af ethylen?
Kan planter lave ethylen?

Spørgsmål der refererer til forelæsning B (bioteknologiske metoder):

Er et plasmid opbygget at jern (Fe), mangan (Mn) og andre mikronæringsstoffer i lige dele?
Er et plasmid opbygget af DNA?
Er et plasmid altid genmodificeret?
Styrer en promoter sekvens hvornår et genprodukt bliver lavet?
Koder en promoter for hvilken antibiotika resistens der overføres til planten?
Hvad kaldes overførsel af nyt DNA til en plantes genom - transformation?
eller bioinformatik?

Spørgsmål der refererer til undervisningsmetoden benyttet i begge forelæsninger:

Deltog du i forelæsning A (kvalitet, ethylen)?
Deltog du i forelæsning B (bioteknologiske metoder)?
Forelæsningerne var afbrudt af øvelser. Husker du nogle af emnerne behandlet ved øvelserne?
Hvis ja, hvilke?
Tror du skift i undervisningsformen har betydning for din indlæring?
Øvelserne kom før teorien om deres specifikke emne, synes du det format skal bruges oftere i andre forelæsninger?
Tror du det har betydning for din læring hvilken rækkefølge øvelser og teori kommer på?
Har det betydning for din forståelse af et emne om du har øvelser i emnet?
Har du et bud på hvordan fordelingen skal være mellem forelæsning og øvelser for at være optimal for din læring?
Har du brugt elementer fra forelæsning A og B efterfølgende i andre fag?
Har du spørgsmål til mig eller kommentarer?

På forhånd tak for hjælpen,
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B Easy exercise

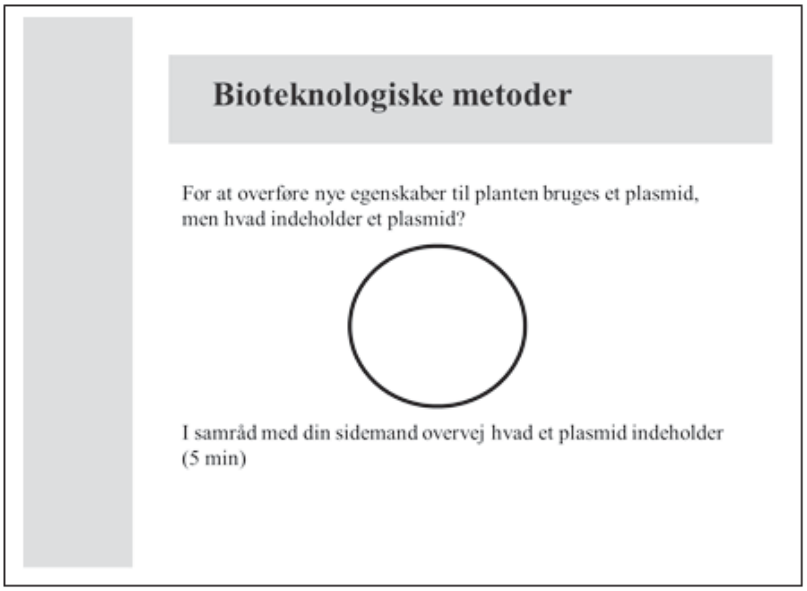

Fig. 17.2. Students' results are discussed in plenum.

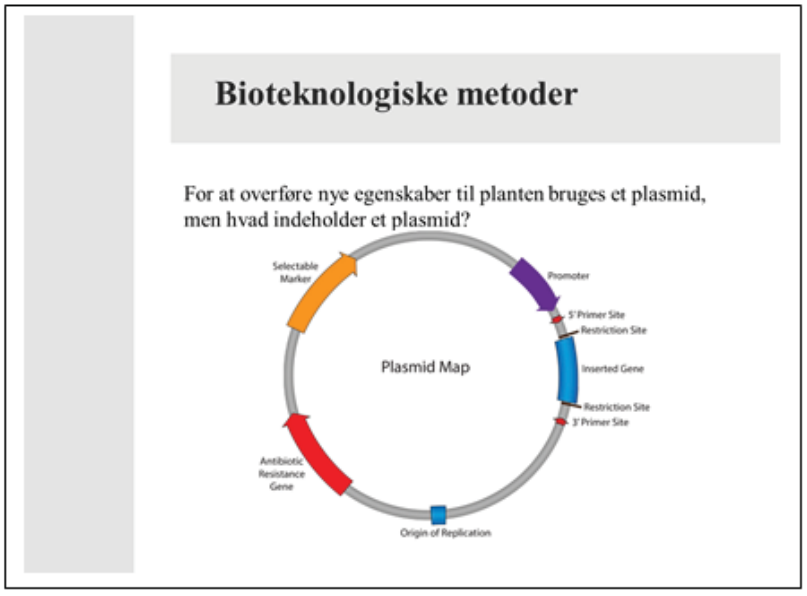

Fig. 17.3. Summary of results from the exercise.

C Difficult exercise

Case: En forædler af *Campanula* sprøjter sine planter med et giftigt kemikalie indeholdende sølv (STS) for at forhindre at plantens ethylen signal resulterer i nedvisning af blomster.

Han søger hjælp til at oprette en renere produktion for både personale og miljø.

Dine indledende analyser viser at C. *xxxx* er ufølsom overfor 0.1 μl · L^{-1} ethylen i 72 timer når denne art sammenlignes C.*portenschlagiana* og C. *formanekiana*. Forsøgsresultaterne er noteret i nedenstående skema (Tabel 17.1). Blomsternes fænotype blev klassificeret som: **Brug Tabel 17.2 til**

Table 17.1. Opgørelse af ethylenforsøg i *Campanula*.

Ethylen	*C. portenschlagiana*		*C. formanekiana*		*C. xxxx*	
0 µl·L^{-1}	1	1	1	1	1	1
0.1 µl·L^{-1}	1	2	1	2	1	1
Tid	0 h	72 h	0 h	72 h	0 h	72 h

at forklare hvad der kan være sket i C. xxxx's ethylen signaltranduktionsvej. Sæt et kryds i tabellen hvis forholdene vil kunne resultere i C. xxxx's fænotype. Students' results are discussed in plenum.

Table 17.2. Skematisk oversigt med mulige forklaringer på ethylenufølsomheden der blev observeret i C. xxxx. A; et eksempel på et ethylen biosyntesegen. B; et eksempel på et ethylen receptorgen. C; et eksempel på et gen der udløser det fysiologiske respons

Gen	A (syntese)	B (receptor)	C (respons)
Overskud af genprodukt			
Mangel på genprodukt			

Correct answers: Lack of gene product B and C could in principle result in the missing response to ethylene exposure seen in C. *xxxx*.

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2015-8/

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