Challenging high-ability students
Karin Scager*, Sanne F. Akkerman, Albert Pilot and Theo Wubbels

Faculty of Social Sciences, Utrecht University, P.O. Box 80127, 3508, TC Utrecht, The Netherlands

The existing literature on indicators of an optimal learning environment for high-ability students frequently discusses the concept of challenge. It is, however, not clear what, precisely, constitutes appropriate challenge for these students. In this study, the authors examined an undergraduate honours course, Advanced Cell Biology, which has succeeded extremely well in challenging students. Methods included interviews with teachers and students, analysis of course materials, and observation of class meetings. As part of their course, the students developed a research programme according to national scientific standards, which they did successfully, according to an external jury of experts in the field. The challenge faced by the students comprised the complexity of the task, the high expectations placed upon them, and the lack of teacher direction. The results indicate that students’ perceived learning peaked in a period of over-challenge and, although students felt worried and frustrated in this period, their efforts increased.

Keywords: challenge; flow-model; gifted; motivation; perceived learning; feedback; undergraduate students

Introduction

The existing literature on indicators of an optimal learning environment for high-ability students frequently discusses the concept of challenge (Clinkenbeard 1994; Freeman 1990; Heller 1999; Lens and Rand 2000; Marra and Palmer 2004; Reis and Renzulli 2010; Sayler 2009). In comparison to average-ability students, high-ability students are quicker thinkers, more flexible in their use of strategies, have better memories, know more, and prefer complexity (Freeman 1998; Shore and Kanevsky 1993; Wallace 2000). Given their ability, it was found that these students in courses aimed at average students often experience boredom (Gallagher, Harradine, and Coleman 1997), leading to a loss of motivation (Hoekman, McCormick, and Gross 1999; Lens and Rand 2000), which in turn can lead to underachievement (e.g. Gentry, Gable, and Springer 2000).

Although the need for challenge is often mentioned in studies on learning needs of gifted students, we have not been able to find a definition of the concept in educational literature. Therefore, we used Webster’s Dictionary, in which challenge is defined as a ‘test of one’s abilities or resources in a demanding but stimulating undertaking’. This definition corresponds with the well-known ‘flow-model’ of Csikszentmihalyi (Csikszentmihalyi 1975; Csikszentmihalyi, Abuhamdeh, and Nakamura 2005). Flow is a state

*Corresponding author. Email: k.scager@uu.nl
of intrinsic motivation in which people are fully engaged in a task for the sake of the activity itself. A crucial condition for intrinsic motivation in flow theory is the compatibility of the perceived levels of skills and challenge. The importance of balancing challenge and ability is also emphasized in several contemporary theories of intrinsic motivation (Deci and Ryan 1985; Pekrun 2006). Pekrun’s control-value theory of motivation posits that boredom can be experienced if demands are either too high or too low. Deci and Ryan (1985), in their theory of intrinsic motivation, discuss the importance of ‘optimal challenge’ in sustaining intrinsic motivation. More recently, Keller and Bless (2008) tested the balance hypothesis, and concluded that ‘the perceived fit of skills and task demands is important with respect to the emergence of intrinsic motivation’ (207).

The level of challenge thus needs to match the level of skills. A person can also experience ‘over-challenge’, meaning that the level of challenge exceeds the level of ability. Over-challenge can lead to negative emotions like worry and anxiety (Csikszentmihalyi 1975, 49), which, in turn, may hamper motivation (Pekrun 2006; Pekrun, Goetz, and Titz 2002; Sansone and Thoman 2005). Creating challenge for students is, therefore, not a straightforward matter. In this study, we wanted to determine how challenge could be created for high-ability undergraduate students in such a way that their (perceived) learning, as well as their motivation, is stimulated.

**Challenging high-ability students**

Many universities within and outside Europe have separate honours programmes for their top students in order to maximize development of their talents. Although these programmes testify to the value universities place on their high-ability students, much is still to be understood about how education should be specifically designed for these students: appropriate challenge seems to be a crucial element in understanding effective education for high-ability students.

Research on the experiences of gifted students at secondary school level indicates that they do not feel challenged by ‘jumping through the hoops’ in the pre-structured courses that dominate most of education (Reis and Renzulli 2010). How, then, should learning environments in university honours courses be designed to better challenge high-ability students? Empirical studies on challenging learning environments for high-ability students at university level are scarce; the vast majority of research has been conducted in primary and secondary education. Moreover, research on the effectiveness of learning environments for gifted students in primary and secondary education has mainly focused on the curriculum level, specifically on the effect of grouping, acceleration, and enrichment, and on combinations of the three. In this study, we focus on the learning environment at the course level in classes where gifted students are already grouped, and we are interested in what aspects of the learning environment constitute challenge. This focus reduces the number of prior research studies available to us, although some findings in studies of gifted students at school have been helpful.

Based on a synthesis of research on gifted students in primary and secondary education, Rogers (2007) points to five lessons which education practitioners should take into account, three of which seem to be related to challenge: offering students consistent challenge, providing opportunities to work independently, and focusing on depth and complexity. ‘Consistent challenge’ refers to a progressive increase in the level of difficulty. Based on analysis of empirical studies on the efficacy of curriculum models for
gifted students in primary and secondary education, Van Tassel-Baska and Brown (2007) suggest emphasizing higher-level skills and inquiry-based learning. From a theoretical point of view, Shore and Kanevsky (1993) arrive at similar conclusions. Based on their review of differences in thinking processes between gifted and non-gifted learners, they state that gifted students benefit from learning from the standpoint of an inquirer. In a similar vein, Snow and Swanson (1992) propose discovery learning, less scaffolding and less structure. Gruber and Mandl (2000) suggest that situated learning – learning that takes place in the same context in which it is applied – is especially suitable for gifted students. In their study, Kanevsky and Keighly (2003) interviewed gifted high school students, focusing on the reasons why they were bored. They found that what these students needed to overcome boredom was more choice and control over their learning, a higher level of challenge and complexity, and caring teachers.

Only a few studies focus on how to challenge high-ability students at university level. Marra and Palmer (2004), in their study on the learning preferences of university students with high and low developmental levels, conclude that high-ability students prefer more independence, less structure, as well as more challenge. Their findings focus on both learning tasks, which should be challenging, and the role of the teacher, which should allow student autonomy. Conversely, in a similar study of students aged 14–24, Freeman (1990) found that those with a high IQ prefer more communication with the teacher and more feedback, findings that seem inconsistent with the conclusions reached by researchers like Marra and Palmer, who suggest that less ‘scaffolding’ and more student autonomy are essential to optimum learning. ‘Challenge’, in these studies, is not clearly defined, but in all cases seems to refer to difficulty, including difficulty of the task (e.g. complex and unstructured) and difficulty of the process (e.g. an independent way of working).

Although the above studies point in same direction when it comes to organizing challenge in education for gifted students, we see two limitations. First, the factors identified as constituting challenge are of a rather general nature. Second, the studies have not considered the level of challenge nor how this level of challenge relates to learning and motivation. As we will describe in the next section, it is necessary to consider the level of challenge in relation to the level of ability, since it is this relation that has been theorized as affecting motivation as well as learning.

Flow-model related to learning and motivation

Csikszentmihalyi’s (1975) flow-model is founded on the assumption that, in a state of flow, learning in itself can be intrinsically motivating. In order to maintain the flow state, tasks should increase in their level of difficulty as the students’ skills, and thus their level of ability, improve. As long as the level of challenge is at, or just above, the ability level, learning and intrinsic motivation go together.

Empirical studies have shown that flow experience is, indeed, associated with positive outcomes such as improved performance (Engeser and Rheinberg 2008; Klein et al., 2010; Nakamura and Csikszentmihalyi 2005; Volmeyer and Rheinberg 2006). Volmeyer and Rheinberg (2006), for example, carried out two studies examining the effect of university students’ flow experiences on their performance in final examinations and they conclude that the degree of flow experience positively affects achievements in this context. Klein et al. (2010) also investigated the effects of flow on learning
outcomes, in this case on a university management course. Their findings show that a state of flow positively affected students’ perceived learning of the subject matter.

A state of flow thus relates to enhanced learning and motivation. The equilibrium between perceived challenge and abilities, however, is fragile. ‘Over-challenge’ as well as ‘under-challenge’ can cause negative emotions (Csikszentmihalyi 1975) and, in turn, negative emotions interfere with motivation (Pekrun, Goetz, and Titz 2002; Phillips and Lindsay 2006; Shernoff et al, 2003). Under-challenge (tasks that are too easy) has been found to lead to boredom (Csikszentmihalyi, Rathunde, and Whalen 1993). In their study of gifted students at high-school level, Hoekman, McCormick, and Gross (1999) found that students’ levels of stress were substantially higher when they were placed in unchallenging classroom settings. Conversely, stress was considerably reduced for these students when they were subjected to higher levels of challenge and they were subsequently successful in meeting the challenge.

According to flow theory, challenge levels that exceed the perceived ability level too much lead to feelings of worry and anxiety (Csikszentmihalyi 1975). Research on the influence of negative emotions on learning has primarily focused on test anxiety. The findings of these studies show that worry is associated not only with loss of motivation, but also with low performance (Hembree 1988, 1990; Pajares and Urdan 1996). In the last decade, research on the influence of emotions on motivation and learning has expanded from outcome emotions, such as test anxiety, to activity emotions pertaining to ongoing achievement-related activities, including frustration when dealing with difficult tasks (Pekrun 2006). Findings suggest that emotions affect interest, metacognition, and effort, which in turn mediate students’ performance (Pekrun 2005).

For the purposes of our research, Csikszentmihalyi’s flow theory (1975) was used as a conceptual framework (see Figure 1). The theory is relevant to our study as it allows us to conceptualize the relationship between the challenge–ability level of a learning environment and the cognitive and emotional state of motivation and learning. We slightly adjusted the original model. Whereas Csikszentmihalyi’s model focuses on the experience and feelings of intrinsic motivation (flow), we are specifically interested in intrinsic motivation and learning as outcomes of the challenge–ability balance.

Figure 1. Flow model.
Understanding the challenge–ability balance seems particularly relevant for honours programmes, which often aim for high standards. For this study, we selected a course that, according to previous student evaluations, seemed to succeed extremely well in challenging honours students to work very hard and achieve beyond their expectations (Wiegant, Scager, and Boonstra 2011). It was apparent, therefore, that studying this learning environment would help to both identify and characterize elements that challenge students to produce their best work.

Three research questions are central in this study:

1. How do students experience the balance between levels of challenge and ability, throughout the course?
2. How do students’ perceived learning and motivation relate to the perceived challenge and ability levels?
3. What factors constitute challenge in this course?

Methods

Context and course

Advanced Cell Biology is a third-year course of the University College Utrecht (UCU), an international Liberal Arts and Sciences honours college. UCU students are carefully selected on their academic excellence, their curiosity, and motivation. Students complete four courses per 15-week semester, each course having a workload of about 200 hours (7.5 European Credit Transfer and Accumulation System credits) consisting of 60 contact hours (i.e. 4 contact hours per week in two sessions) and approximately 140 hours of self-study. The central task for students in the Advanced Cell Biology course was to formulate, in groups, a research programme consisting of three separate doctoral research proposals. In addition, the research programme needed to meet the criteria used for professional research proposals. At the end of the course, students presented and defended their proposal before an expert jury. The course was strongly student-driven. The teachers devised the broad parameters but, within these general guidelines, the students were free to make their own decisions about the content of their research project, the organization of processes, as well as the nature of class meetings. The course comprised four phases: (1) orientation; (2) formulating research questions; (3) finding and choosing methods and techniques; and (4) writing, presenting and defending the research programme. Table 1 provides a brief description of the four phases.

Assessment by the jury of the novelty, originality, feasibility, and readability of the final product, the quality of the presentation, and the way the students defended their work before the jury all formed important parts of the students’ final grade. It should be stressed here that each of the students was responsible for the whole programme and that the jury could question them on all aspects of the programme. A more detailed description of this course can be found in Wiegant, Scager, and Boonstra (2011).

Participants

Participants in the study are the two teachers who delivered, and the 13 students who took the course. All 13 students who entered the Advanced Cell Biology course in 2010 are life science majors who had completed the prerequisites of an introductory biology
course (100 level) and a textbook-based cell biology course (200 level). However, the students had virtually no laboratory experience, with the exception of a 200-hours science laboratory module.

Data collection
A case-study approach was used, with four methods of data collection, including the course design (provided to the students in written form), an interview with the teachers, course observations and student interviews (see Table 2).

Course design
The course design as described in a paper by Wiegent, Scager, and Boonstra (2011) was used to provide contextual data and to inform the researchers. The documentation includes descriptions of the aims, learning activities, and results of the course, as well as evaluations by students, alumni, and jury members who had participated in the past.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Aims and activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation</td>
<td>The aim of this phase was for students to master the current state of knowledge about the theme, to learn the methods of researchers in the field, and to develop a critical approach. The teachers defined the theme; this year’s theme was ‘epigenetics’. In the first week, the course procedures (session 1) and the content (session 2) were introduced by the teachers. After these introductions, students received a series of primary articles and review articles on the theme, and were expected to present the findings in pairs during the first three weeks. This phase ended with the students’ decision on the topic of research.</td>
</tr>
<tr>
<td>Research questions</td>
<td>In this phase, students focused on the research field covering their interest by searching primary literature and review papers. The findings were presented and discussed in class. From this phase on, the students were responsible for the organization of class meetings. At the end of the second phase, the students were supposed to have formulated their research topic (title of the projects) and their research questions, and to have produced a background paper.</td>
</tr>
<tr>
<td>Research methods</td>
<td>In the third phase, students needed to identify research methods and techniques, and plan and budget their projects. This required more reading, focusing on the methods sections, and finding expert help by contacting scientists in the field through visits to laboratories. Findings, ideas and proposals were discussed in class and in group meetings outside class hours.</td>
</tr>
<tr>
<td>Presenting and defending</td>
<td>In the final phase, students needed to relate the group projects to a whole, put it all on paper, and prepare for defending the programme for the expert jury. The jury defence was formal; the students first presented their proposals in about two hours, and defended their proposals during a 1.5-hour questioning session by the jury members.</td>
</tr>
</tbody>
</table>
Interview with the teachers

The teachers were interviewed by the first author before the course started. The interview was semi-structured, and questions concerned the aims of the course, the course design, the role of the teachers, and the student-led approach of the course.

Course observations

The course was observed by the first author, who attended 19 of 29 of the class meetings (about 40 hours in total), with field notes and audio-recordings taken. Field notes (reported in 58 pages) contained information on all interactions, reporting specifically who said what at what time. Contributions observed included the following: (a) a student presentation; (b) a teacher’s instruction; (c) a question and answer session between students and teachers; (d) a discussion between students, and between students and teachers; (e) a suggestion, by either students or teachers. All contributions were noted in an abbreviated way, as were notable signals of non-verbal communication.

Interviews with students

All 13 students were interviewed individually in the week after the course ended, in a 45-minute semi-structured interview that was audio-taped. Students were informed that their individual statements would not be discussed with their teachers, and that their experiences and direct quotes would be used anonymously in subsequent reports. All students gave their consent.

Four themes were central to the interviews: students’ learning, their motivation, their perceived ability, and perceived challenge. The perceived challenge was conceptualized as the level of difficulty experienced by students. The stimulating aspect of challenge, referred to in Webster’s definition, was considered an effect of the difficulty–ability balance. The perceived level of ability was conceptualized as the confidence students had in successfully completing the course. The passive role of the teachers in this course was an important feature, and it was assumed to be a key factor that affected the students’ experiences. Therefore, when students did not

Table 2. Overview of research questions and methods.

<table>
<thead>
<tr>
<th>Storylines</th>
<th>Student interview</th>
<th>Observations</th>
<th>Teacher interview</th>
<th>Course materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ1 How do students experience the balance between levels of challenge and ability, throughout the course?</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ2 How do students’ perceived learning and motivation relate to the perceived challenge and ability levels?</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ3 What factors constitute challenge in this course?</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
mention the role of the teachers spontaneously, they were asked, specifically, how they experienced the role of the teachers. At the end of the interview, students were asked about their future plans.

At the time they were interviewed, students had just finished the course, having been praised highly for their work and presentations by the jury. The ‘storyline method’, which has been used successfully to retrospectively improve teachers’ learning experiences (Henze, van Driel, and Verloop 2009; Meijer, de Graff, and Meirink 2011; Beijaard, van Driel, and Verloop 1999), was used to allow students to reconceptualize their experiences over the period of the course. In the storyline method, students draw a line, visualizing their experiences along that timeline. In our interviews, students were asked to draw four lines, capturing the development, throughout the course, of their perceived learning, motivation, confidence (ability), and course difficulty (challenge). They were provided with pre-structured graphs showing diagrams, with the 14 weeks and 4 phases of the course set out on the horizontal axis, and a scale from -5 to +5 on the vertical axis. An example of such a graph is shown in Figure 2.

The students were asked to think aloud while drawing the lines. The thinking-aloud procedure gave an insight into how the various processes (learning, motivation, confidence, and course difficulty) developed, and allowed the students to question what affected these processes. In order to help students articulate potentially unnoticed factors, such as those that may be deemed too obvious to mention, they were also asked what could have caused their learning to decrease to levels below the lowest points on their graph.

**Data analysis**

To answer the first two questions, about students’ experience of the balance between challenge and ability levels, and the relation with learning and motivation, we analysed
the four storylines that were drawn and explained by all the students in the interviews. The storylines were not only used as means to activate students’ memories, but also to generate quantitative results by averaging the weekly scores in the graphs of the 13 students on the scale from -5 to +5. The scale was regarded as an interval scale, with the 14 weeks as points of measure. The weekly scores from the 13 students were taken from their drawings in order to discover the mean lines, standard deviations, and correlations. The visualization of these mean lines provides the trends in students’ experiences of learning, motivation, ability, and challenge in the four phases of the course. To complement the quantitative results, the transcribed interviews were read with care, and students’ comments on the four pre-structured interview themes (learning, motivation, ability and challenge) were selected and coded, using NVivo (a qualitative data analysis computer software package).

To answer the third question, regarding the challenge-factors, we conducted an analysis in three steps. First, we examined the full transcriptions of the interviews with students, searching for elements in the learning environment that students referred to as difficult or challenging. Although their perception of course difficulty was the most explicit topic in the fourth interview theme, students also mentioned course difficulties they had experienced in earlier parts of the interview (while talking about learning, motivation, or confidence during the course). All the students’ comments about the level of difficulty and challenge they experienced were selected and coded, using a sequence of open, axial and selective coding (Boeije 2010). The final code list was a result of the iterative process of testing, discussing and adapting codes until the first and second author reached consensus on the codes to be used (Boeije 2010). This process lead to three codes representing challenge factors: task complexity, lack of guidance, and high expectations. In a second step, student comments were categorized and sub-coded, during which the first and second author compared and discussed their categorization until consensus was reached.

In step three these codes were used to explore the three other data sources to ground the realization of these three challenge factors in the learning environment: the field notes of the class observations, the transcribed interviews with the teachers, and the course description. These additional data sources were used to check whether the experiences of the students corresponded with the teachers’ aims as described in the course description and/or reported in the interview, as well as with the observer’s notes. Further, the field notes and recordings of the observations were used to determine the contributions of the teachers during class time.

**Results**

The results section opens with a description of the students’ experiences of the processes of learning, motivation, ability and challenge throughout the four phases of the course (research question 1), and describes how the processes relate to each other (research question 2). Next, we consider the third research question focusing on what constitutes challenge for students on this course. Typical students’ quotes are included throughout to support and illustrate the findings.

**Reported levels of challenge and ability, and their balance throughout the course**

The students’ challenge scores show, on average, an increase through phases 1 and 2 of the course, climbing to a peak in the third phase of the course, where students needed to
find ways to answer their research questions (see Figure 3). The level of challenge decreased in the final week, when students had to present and defend their proposals before the jury. The standard deviation of the challenge scores was about 1.0 in all phases, except for this last week, where it rose to 1.8. Some students ($n = 3$) experienced the presentation and defence for the jury as being very difficult, but most ($n = 10$) reported a decrease in challenge in week 14 because they had practised their presentations several times in the previous weeks. When looking at the individual graphs, all but one student located the highest levels of challenge somewhere during phase 2 (research questions) and 3 (research methods) of the course.

The mean scores of ‘ability’ showed a large standard deviation (SD = 2.3). Only two students reported stable confidence in their ability to successfully complete the course from the beginning to the end. All the other students drew erratic graphs for their perceived ability. The ability lines varied not only between students, but also for individual students between the four phases. Perceptions of ability vary for different reasons, depending both on personal and group differences. Students’ perceived ability at the beginning of the course could vary because of their perceived level of basic knowledge of cell biology, in comparison with their peers.

**High challenge and low perceived ability: worry and frustration**

When we look again at Figure 3, the largest distance between students’ challenge and ability lines are between week 8 and week 12. Although the students’ ability graphs show significant variations, 11 of the 13 students’ drawings show this gap between ability and challenge in this period. Emma’s comment on this period illustrates students’ experiences:

I think that was the up and down part. At some points, for some questions, it was really easy to solve them, with other things it was way too hard, and we had no idea how to do it.
We were emailing with people, and reading maybe 50 articles, and still we weren’t sure how to do it. … At some point, we thought it was impossible.

Here, Emma describes a period of worry and frustration experienced by her group. The other two groups also reported that they had one or more frustrating periods during phase 2 or 3. Students’ confidence dropped as a result of failing to formulate appropriate research questions, or ways to answer their questions, and could subsequently increase steeply when a good question or a feasible method was found.

**Relations between challenge, ability, and perceived learning and motivation**

The perceived learning curves of the 13 students show large similarities (SD = .8), growing steadily to a peak in the third phase (see Figure 4).

Students’ learning increased steadily to a peak in the third phase. In this phase, where students had formulated their research questions and needed to find methods to be able to answer them, students \((n = 12)\) perceived that they learned the most. In the last phase, when students wrote down their research programme, scores for learning dropped a little.

Students’ motivation started low as well in the orientation phase: they reported that they were not yet motivated because they did not yet have a clear picture of what was going to happen. Students were relatively passive during orientation, working much less hard than they would later on. For most students, their motivation increased in the second and third phase of the course, although progress was erratic. The standard deviation was quite high (1.6).

Figure 4 shows that students perceived their learning gain, as well as their motivation, to be highest during week 8 to 12, when the challenge was at its peak, while

![Figure 4. Means of the graphs for ‘learning’, ‘motivation’, ‘challenge’, and ‘ability’ throughout the 14 weeks.](https://via.placeholder.com/150)
their confidence in their ability was at its lowest point. To check whether this pattern reflected the quantitative data retrieved from the graphs, correlations were calculated. A correlation of .51 was found between learning and challenge ($p > .01$), but not for motivation and challenge or motivation and learning. This correlation pattern is also reflected in students’ descriptions, for example Susan’s:

During research questions, we were researching, but we’re not interpreting as much as we should have been. But then [during research methods] it kicked in. Every single thing that I was doing was completely involving all that I knew. That’s why I was putting 5’s here. I was engaging all my abilities that I already had here, and the ones that I needed to develop. … We were not able to grow any more when we were doing the research methods.

Susan, like many other students, assessed her learning in this period with a 5 (on a 5-point scale), and she describes an intense learning experience, resembling the flow experience Csikszentmihalyi (1975) describes. The learning curve of students remained high during these weeks; their motivation, however, fluctuated in this period, and even drops below zero for some students, including Susan:

Oh, and I think somewhere here during the methods, it should go below zero a little bit. This was when nothing was going right. We were looking at methods and we were not finding what we were looking for, and we were again rephrasing questions, we weren’t getting any criticism from other groups, with peer review, we wouldn’t get any feedback, and that was very frustrating, and when there is nothing, nothing coming your way, that is extremely frustrating. It was entirely unmotivating. Oh, but this [end of phase 3] was high again. [Drawing]

Obviously, during this period Susan was not experiencing flow in the sense of enjoyment. Although she was fully immersed in the task during this period, she lacks the positive feelings that accompany flow. This pattern of increased drive to work and temporary loss of enjoyment was found in most of the other students’ stories and storylines as well ($n = 10$) during this stressful period. These students described feelings in terms of ‘anger’, ‘frustration’, and perceived the task as ‘impossible’ in that period. Nonetheless, students reported an increase of time investment and learning gain during this period.

According to the students, their motivation in these low periods was affected by the group interactions. In two groups, social support and the encouragement of peers helped them through the dips, whereas in one group the tensions increased because of problems between team members.

Students not only learned a lot on this course, they also performed very well. According to the jury, the students produced excellent work. All three of their research proposals were relevant, innovative, very well motivated and presented, and grant-worthy, except for the feasibility aspect: according to the jury, the proposals were still too ambitious.

Factors constituting challenge

Three factors could be distilled from the aspects students mentioned were constituting the challenge they experienced in this course: complexity, lack of teacher direction, and high expectations of both teachers and students. In Table 3, the number of utterances and students are shown.
Other challenge factors that students mentioned were as follows: the group work \((n = 2)\), the professional level of the task \((n = 2)\), the assessment by external experts \((n = 1)\), and the restricted time frame \((n = 1)\).

In the following, we describe how students experienced these three factors, and compare their views with the findings of the analysis of course materials, the interview with the teachers, and the observation data.

**Complexity**

The task of writing a research programme was complex for the students in several ways: the novelty of understanding and evaluating primary papers, the interplay between the various standards of a research proposal, and the dynamic of the process, generated by the need for groups to collaborate. The first complexity factor was the novelty of reading and judging primary articles, especially the methods sections, as described by Taniah:

> Research methods, that’s a whole different story; that was hard, very very hard. Sometimes you read these techniques, and then you think, how did they [the authors] come from this step to the next, they [the authors] don’t explain, and you go to the supplementary information, and then that’s just not English.

Taniah refers to the ‘leap’ students needed to make on this course, from the relatively simple task of learning from books on previous courses to determining what information was needed, searching for it themselves, and judging its value. The ways in which the students described the novelty of understanding and critically assessing primary articles can also be recognized in the course design and the observations. Firstly, the reading of primary articles is one of the planned learning goals of this course. As explained in the course description (Wiegant, Scager, and Boonstra 2011), students on this course need to bridge the gap between reading textbooks and research articles. From textbooks, students receive information that is already selected, organized, interpreted, and explained by the authors of the book. However, primary articles on cell biology explore the subject in much greater depth and are quite technical and jargon-laden, making them difficult to read and understand.

Unlike textbooks, the validity of knowledge presented in primary articles lacks consensus amongst scientists, and this requires the students to read critically,
detecting inconsistencies in the current knowledge (which is new to them) and using this for their own research questions. The emphasis on critical reading was visible during the observations. In the first phase of the course, teachers stimulated critical reading by modelling the behaviour, asking detailed questions about the methods researchers used, or the conclusions they drew, and at the end asking students how they assessed the paper.

A second aspect of the complexity mentioned by the students was the interplay of the various standards of a research proposal, as Samuel explains:

The problem-solving aspect is something I really, really like. ... You have to think about a lot of practical things, it has to be feasible. Think of a lot of other possibilities, like ‘what if this is the case, how would that affect my methods, or questions?’

his aspect of complexity was reflected in both the course description and the observations. According to the course description, the knowledge from the literature needed to be translated into questions that have not yet been answered but for which the solution can be obtained in the laboratory, using appropriate methods and techniques. This interplay between demands demarcates the main assessment criteria for research funding agencies in general, as well as for the students’ proposal. This aspect of complexity could also be recognized in the course observations. During class meetings, the teachers would frequently question the interplay of the demands of a research proposal. The novelty demand, for example, was subtly inserted into the group discussion about a possible research question, when the teacher would ask: ‘Did someone check how many hits you get on that mark in PubMed?’

A third aspect of complexity for students was the need to adjust their plans to changes in the environment during the process. Groups needed to change their questions and methods on several occasions in order to keep the connection between the three proposals or because new research studies were found which partly answered one of their questions. Field notes of the observations, as well as the course description, reveal that the teachers deliberately planned the interconnectedness of the three groups as part of the course design. Teachers told students on several occasions that researchers in the field of science work in groups on interconnected research programmes. The interdependency between groups was reinforced by giving students responsibility for the whole programme and not only for their own group project.

Lack of teacher direction
The course was designed to be largely student-led, which students experienced generally as a lack of direction by their teachers. This lack of direction comprised two aspects: a lack of structure and a lack of feedback.

Lack of structure. As students explained during the interviews, they are used to teachers taking the lead and structuring the course by setting the deadlines, examinations, and organizing class meetings. On this course, students were supposed to take over this role, which they found hard, specifically in the first phase of the course. Jesse explained the way in which students perceived this problem:

I think it was the lack of idea of what we should do. It was really not directed, we weren’t that guided, how to do it. And maybe because we didn’t really put strict deadlines, we
constantly moved them. So it was the lack of structure … the lack of teacher control. They weren’t organizing the classes, it was all on us, we had to organize, pick the deadlines. I think the feeling of responsibility was the hardest thing.

Despite this perception, the course description and observations revealed some general guidelines. The teachers set out the assignment, the topic of epigenetics, the group work requirement, the date of the jury presentation, and the structure of the first few weeks, in which students were supposed to familiarize themselves with the field by presenting research papers in pairs. Furthermore, students received a list of tips from the previous group, and the final products of six of the previous classes. Within these parameters, students had to make their own decisions about the content of their research project, the organization of processes, and the class meetings. During the observations, the teachers’ intention that the process should be student-led was clearly visible. Teachers kept silent for most of the class time, occasionally posing critical questions. After this first week, the teachers literally ‘handed over the chalk’ to the programme leader, took their place at the side of the class, and stayed there throughout the rest of the course. Even in the observed class meeting where the teachers were most active, they did not speak for more than 5% of the meeting. Furthermore, we observed that teachers never intervened in decisions concerning the process or the content of the task. They offered suggestions now and then, such as ‘why don’t you talk about this some more in the bar or some other non-formal setting?’, but that was one of the most direct suggestions the teachers provided.

**Lack of feedback.** One of the most difficult aspects of the course for students was the lack of feedback (n = 13). Especially in the first three phases of the course, students said that they had been ‘frustrated’, ‘grumpy’, and ‘complaining’ about the lack of feedback from their teachers. In the last phase, students did receive feedback on both their draft proposal and their rehearsal of the jury presentation. The lack of feedback was expressed in various ways. Firstly, students mentioned their need for the teachers’ expert judgement, as Faizal explained: ‘It’s just the thing that you need experience there. Our teachers would know what we were doing wrong, but sometimes we waited for their comments, and we figured out ourselves that we were wrong’. Secondly, there was the need for acknowledgement, as Jesse said: ‘We were still learning to be independent, and then you sometimes wanted a bit of acknowledgement’. Thirdly, students felt that they would have benefited from some confirmation, as Alex noted: ‘I think here, with the questions, it would have helped if they would have said, “ok, go for this”’. These utterances reveal a need for teachers’ judgement on students’ performance, and some confirmation or clues about the direction of their next step. The teachers did, however, offer critical questions throughout the process, which was understood as feedback by some students, as Sarah explained during the interview: ‘In asking those questions they also let us know in a small way that it was time to start with the next step, with the methods for example’.

The analysis of the observations, as well as the interview with the teachers, concurred with the experiences of the students. In the interview, the teachers explained their approach: ‘if we do give feedback, students are inclined to sit back and rest, and we don’t want that. Moreover, we think that it is important that it will be their own product, something that they can be proud of’.

Teachers explained they were aware of the frustration students experienced, as they explained during the interview. Their seven years of experience with this course taught
them that the lack of feedback would eventually challenge students to develop the critical attitude of a researcher and that was one of the main objectives of the course. Observations of class sessions also correspond with the experiences of the students. During the class meetings, the teachers, indeed, did not provide explicit feedback in terms of giving information on the quality of the students’ performance and progression, nor did they provide confirmation or reassurance. We observed that the teachers did, however, facilitate students to assess their own performance, by handing students some examples of products of previous years’ students, by asking critical questions, and by initiating a peer-review system.

Although students lacked the feedback from their teachers in the first part of the course, in hindsight all of them understood the approach of the teachers, as Taniah explained:

I think feedback would have helped. But then again, I think it was a good thing that they didn’t. We didn’t need that reassurance from people; we should be able to know if we were doing good or not.

Students conveyed ambiguous feelings about the lack of teacher guidance. At the time, the quietness of the teachers was difficult for the students, but after the success experienced during the positive assessment by the jury, feelings of pride and satisfaction replaced earlier frustrations.

**High expectations.** A third factor constituting the challenge, according to the students, was the high expectation of their teachers as well as of the students themselves. The teachers conveyed their expectations by mentioning the achievements of previous groups, as Sarah explains: ‘The fact that the previous years did good and the teachers told us that they all did good and that none of them did bad during the final presentation, that was putting the standards high. You need to keep up with that...’

The course description and the interview with the teachers were not entirely in line with the students’ experiences at this point. Teachers assumed that the students’ performance goals would be raised primarily by the expert jury assessment, and not so much by their own expectations. For Alex, however, the jury assessment primarily added to the feeling that they had to live up to the expectations of the teachers: ‘you know that the level needs to be high. He [the teacher] emphasized that we needed to deliver high quality, otherwise they would look bad as well’. Students did not only attribute the high expectations to their teachers: the majority also wanted to achieve for themselves. Firstly, students, for example Marieke, felt that having high achievement goals is a part of the UCU culture: ‘the fact that we really wanted to do well [Why?]. I think it’s just a trait a lot of people at UC have’. Other students, like Gizelle, related her aim to do well to the student-driven nature of the University: ‘I believe that it works very well that it is all up to us, our own initiative: you are not forced to work, but you do it anyway. We have put a lot of time into the project, not because it is compulsory, but because you want to’. Here, Gizelle also related two of the challenging aspects of the course to each other: the autonomy (lack of teacher direction) and her high expectations. The autonomy apparently stimulated her to focus on her own goals and standards, working hard not because she was told to, but to satisfy her own need for mastery of the writing of a research proposal.
Conclusions and discussion
Three questions about challenging gifted students were central in this study. Firstly, using Csikszentmihalyi’s (1975) flow-model, we explored how students experienced the balance between perceived challenge and ability, and secondly, how this balance related to learning and motivation. Thirdly, we examined what characteristics of the learning environment challenged these high-ability students. We will now discuss the findings, starting with the first two questions as their findings are related.

Students’ reports of the processes of their learning, motivation, challenge, and ability showed an interesting pattern. Students’ perceived learning was at its peak in the period in which the challenge level most exceeded the ability level. According to Csikszentmihalyi (1975), if challenge exceeds perceived skills, people feel worried and anxious, which are negative emotions that decrease feelings of flow and intrinsic motivation. Students in this case study felt that there was a significant difference between their perceived ability level and the level of challenge, especially in the third phase of the course, and indeed reported feelings of worry and frustration. Students’ motivation graphs fluctuated heavily during this period. A closer inspection of students’ stories about their motivation, however, revealed that, although their enjoyment decreased during these periods of decline in motivation (as shown in their graphs), their drive did not weaken, and their efforts even increased. Students apparently interpreted the concept of motivation as a combination of drive, which they emphasized in their stories, and enjoyment, which guided their graphs. Students’ learning graphs were at their peak during this period of fluctuating motivation. This finding is unexpected, given that negative emotions have been understood to impede intrinsic motivation (Csikszentmihalyi 1975; Larson 1988; Meyer and Turner 2006). An explanation for students’ increased efforts, despite a lack of enjoyment, could be found in the support that was experienced from their peer group. Firstly, students in their project groups cooperated in a face-to-face mode, reading, writing, emailing and discussing together. In the busiest phase of the course, students kept working most evenings, and all through the weekend. Face-to-face settings for group work have been found to support intrinsic motivation significantly better than virtual group work (Järvela, Järvenoja, and Veermans 2008). Secondly, the groups could have developed a sense of collective efficacy. Collective efficacy – a group’s shared belief in their collective power to produce desired results – affects group motivational efforts, and engenders persistence in the face of difficulties (Bandura 2000; Goncalo, Polman, and Maslach 2010). Thirdly, several students reported that the social support of their team members helped them during the moments of crisis they experienced during the difficult phase in the course. We accordingly assume that social support can prevent or overcome situations of over-challenge and the accompanying feelings of worry and frustration. This assumption concurs with findings of Bakker and Demerouti (2006), who studied factors that cause or prevent burnout in work settings and found social support to be one of the most important factors that balance out high job demands. Thus, although the enjoyment associated with intrinsic motivation and flow was not there in this difficult phase of the course, the drive and persistence were maintained, generated by the social support of the group.

The third research question focused on what challenged students to work so hard and perform so well on this course. The complexity of the task, the lack of guidance, and high expectations were the three factors that constituted the challenge for the students. The complexity of the task is conceptually closest to the ‘challenge’ axis in

Studies in Higher Education 17 Downloaded by [University Library Utrecht], [Karin Scager] at 02:44 08 November 2012
Csikszentmihalyi’s (1975) flow-model. On this course, students described the task complexity in terms of novelty, interplay of standards, and dynamism.

The lack of teacher direction (both structuring and feedback) was the second factor we found. The lack of structure refers to the student-led character of the course. In the first half of the course, students experienced a ‘lack of guidance’. They were supposed to regulate their own learning and research process, which confused them at the beginning. The way this lack of direction was experienced, however, evolved during the course into more positive feelings of independence, responsibility, and ownership of their project. Research on self-regulating learning shows that students’ perception of internal control results in more engagement, higher achievement, and higher self-esteem, whereas external control results in lower achievement and passivity (Pintrich and Zusho 2007), and this research is borne out by our results. Although from phase 2 onwards the course was led by the students, they did not convey a perception of control: students felt more ‘lost’ than ‘in control’ in that period. This indicates that student autonomy did not automatically or immediately lead to feelings of internal control and its positive outcomes; a period of adaptation was needed.

The way in which a lack of teacher feedback was perceived to constitute part of the challenge was an interesting finding. In educational literature, feedback is described as one of the most powerful elements of an effective learning environment (Black and William 1998; Hattie 2009; Sadler 1989). In our study, students did express the need for feedback from their teachers, but at the same time, they proved to be able to perform exceptionally well without it. Apparently, students learned to judge the quality of their work themselves, which was exactly what the teachers were aiming for. Withholding feedback is advocated by several scholars (Nicol and Macfarlane-Dick 2006; Sadler 1989; Yorke 2003), who argue that teacher-transmitted feedback keeps students dependent on their teachers and interferes with self-regulated learning. According to Sadler (1989, 121) ‘students have to be able to judge the quality of what they are producing and be able to regulate what they are doing during the doing of it’. In this view, students need to be empowered to judge the quality of their work, which is precisely what the teachers of this course did. Students were provided with exemplars of good work and critical questions, and they were stimulated to critically assess each other’s work. Teachers did not impose their views, but they were available if students needed them. The students, in hindsight, valued the restrained attitude of their teachers because it increased their sense of ownership and pride. At the time, however, the lack of teacher guidance was not beneficial for students’ enjoyment. The students, especially in the first half of the course, had felt lost and were not very happy with their teachers, saying they had been feeling ‘frustrated’, ‘grumpy’, and were ‘complaining’ about the lack of feedback and structure. The teachers, however, held back from intervening, despite the obvious need from students for feedback. This allowed students to adjust to their independence and take the responsibility for their project. These negative feelings might be expected to have a detrimental effect on the interpersonal relation between students and teachers, which is found to be an important element of effective teaching (Hattie 2009; Wubbels and Brekelmans 2005). However, our study shows that the students’ appreciation of their teachers was positive, which could be explained by the fact that, in hindsight, they understood that the teachers’ approach was an empowering one.

The high expectations the students experienced both from their teachers as well as from themselves was the third factor we found. High, but appropriate, teacher expectations have been found to be effective for all students (Hattie 2009). In our study,
students felt strongly that their teachers were critical and expected high standards in their work, and they wanted to meet these expectations. According to Phillips and Lindsay (2006), high expectations have the risk of generating stress and anxiety, an emotional state interfering with motivation. On this course, the high expectations contributed to the challenge and associating feelings of worry and frustration.

In conclusion, the combination of the complex task, the lack of teacher guidance, and the high expectations increased students’ worry and insecurity during the course. In hindsight, however, these factors made up the challenge, and increased their efforts and perceived learning. The results of this study allow us to propose a different view of Csikszentmihalyi’s (1975) flow-model, one that is specifically interesting in the context of teaching high-ability students. The processes students described led to the notion that the balance between challenge and ability was lacking during several weeks; students were over-challenged in that period, during the course, experiencing various emotions in the process. Positive emotions were experienced when students made progress, which concurs with Pekrun’s (2006) control-value theory of intrinsic motivation. However, maximum effort and (perceived) learning were experienced when the perceived challenge exceeded the level of ability the most, and students felt worried and frustrated. These findings indicate that the balance between ability and challenge is vital for enjoyment, but not necessarily for effort, persistence, and learning. Specifically, the concept of challenge, a commonly used but seldom operationalized concept in the field of giftedness, has been central to our study. We recommend further research to discover whether the three-factor model of challenge (complexity, lack of guidance and high expectations) applies to challenging university courses in other disciplines.

Acknowledgements
We would like to thank Johannes Boonstra and Fred Wiegant, teachers of the Advanced Cell Biology course, for their frank and unreserved cooperation.

Note
1. We use the word ‘frustration’ instead of Csikszentmyhalyi’s ‘anxiousness’, as frustration better captures the experiences of the students in this study.

References


