Attitudes towards mathematics as a subject, and mathematics learning and instruction in a trans-disciplinary engineering study

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This article explores student attitudes and preferences in learning and teaching of mathematics in engineering studies that transcend the division between technical, scientific and artistic disciplines. For observing such attitudes, we have developed a model that relates the attitude towards mathematics as a subject with the attitude towards mathematics learning and instruction. Data comes from a study at the Media technology educational program of Aalborg university. The study used attitude and preference questionnaires, and observations and interviews with students. The results show that media technology students are not confident in mathematics and consider mathematics to be a difficult subject. Nevertheless, they recognize the importance of mathematics both in their studies and in general. Moreover, students favour learning on their own or together with their peers over learning supported by a teacher. We propose that these findings inspire reforming mathematical education for such engineering students.

The rapid pace of technological and scientific change is driving profound changes in the role of engineering in society. The transitions in the global economy change the workforce needs and as a result the nature of engineering practice has been dramatically changed. Nowadays, engineers should be equipped with broader skills than just the mastery of scientific and technological disciplines (Spinks, Silburn & Birchall, 2007). Therefore, there is demand for a paradigm shift in engineering research and education in order to better address the needs of a rapidly changing world (Duderstadt, 2010).

Over the past years, engineering education has been challenged to embed creativity and innovation into undergraduate and postgraduate programmes, in order to produce graduates who can easily adapt to these

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changes (Badran, 2007; Jørgensen & Busk Kofoed, 2007; Zhou, 2012). Moreover, a number of engineering programs have arisen that transcend the division between technical, scientific and artistic disciplines (e.g. architecture and design, media technology, sustainable design). In relation to mathematics education, this new development has led to a transposition from an industrial use of mathematics, where it is employed intensively by mechanical and construction engineers as a tool in order to develop products and build constructions, towards a situation where mathematics is increasingly used as the actual building blocks in various new digital products and creative expressions. This transposition has implications on how mathematics should be taught in such newly arisen engineering studies.

The specificities of mathematical education for engineering students have been widely investigated (Bingolbali, Monaghan & Roper, 2007; Maull & Berry, 2000; A. Morgan, 1990). However, little is known about the emerging field of mathematics education in studies, where engineering is combined with other fields. The literature has yet to discuss how different and more media-oriented modes of application influence the students' conception and attitude towards mathematics. The teaching of mathematics to students of such disciplines represents a challenge to the education system; typically these disciplines are more related to arts and humanities, and constructed in specific opposition to technology and science. Moreover, mathematical applications in these disciplines are closely associated with technology. Therefore, we have been conducting research for exploring the challenges in teaching mathematics in such engineering disciplines and how technology can support this teaching (Triantafyllou & Timcenko, 2013). Since research has shown that student attitudes towards mathematics is an important factor for the achievement of the intended learning goals (Pierce, Stacey & Barkatsas, 2007), we decided to investigate how students in these disciplines approach mathematics.

This article presents our study that addresses this issue, which was conducted in the Media technology program of Aalborg university. We consider Media technology to be representative of the aforementioned studies since it is a trans-disciplinary educational program combing engineering, arts and humanities. The study presented in this article addresses the following research question:

> What attitudes do media technology students hold towards *mathematics as a subject*, and *mathematics learning and instruction*?

In the following section, we discuss and attempt to define the notion of attitude towards mathematics.

Attitude towards mathematics

Many studies have investigated student attitudes towards mathematics as a subject (Aiken Jr & Dreger, 1961; Fennema & Sherman, 1976; Wilkins & Ma, 2003; Zan & Di Martino, 2008). More recent studies combined attitudes towards computer use and technology along with attitudes towards mathematics (Pierce et al., 2007; Pilli & Aksu, 2013; Reed, Drijvers & Kirschner, 2010). However, there is not consensus in the literature on the definition of the notion of attitude as different studies adopt different definitions (Di Martino & Zan, 2015). Therefore, we present in the following an overview of different approaches to the notion of attitude and then we clarify the perspective adopted in this article.

Various researchers such as Ruffell, Mason and Allen (1998) and Sonnert, Sadler, Sadler and Bressoud (2015) have adopted attitude as a multi-dimensional construct consisting of three interwoven components: (1) the cognitive, which is compiled by the beliefs that the individual has regarding mathematics, (2) the affective, which contains (a positive or negative) feelings that one associates to mathematics, and (3) the conative, which is defined by expressions of behavioral intention. As Di Martino and Zan (Di Martino & Zan, 2015) point out, the multi-dimensional character of attitude in this definition does not allow for it to be quantified with a single score. This has lead researchers adopting this definition to combine qualitative methods, such as individual and group interviews, with quantitative ones, such as questionnaires and attitude scales.

Other researchers have proposed a definition focusing mainly on the affective dimension, which describes attitude as the emotional disposition toward mathematics, i.e. the degree of affect associated with mathematics (Evans, Hannula, Zan & Brown, 2006; Fennema & Sherman, 1976; Hannula, 2002). This widely adopted definition leaves out the cognitive and conative aspects but it is unclear how the cognitive and conative (i.e. beliefs) aspects can be separated by the affective (emotions) aspects in many questionnaires that adopted this definition (Di Martino & Zan, 2015).

In this article, we adopt attitude as a construct containing both cognitive and behavioural aspects. We consider attitude towards mathematics as part of student motivation. Therefore, we describe attitude towards mathematics as a constellation of variables included in the students' motivational level (Haladyna, Shaughnessy & Shaughnessy, 1983). In this motivational model, attitude towards mathematics is separated in three evaluative variables: (1) mathematics confidence, (2) affective engagement, and (3) mathematics value. We adopt mathematics confidence as "a student's perception of their ability to attain good results and their assurance that they can handle difficulties in mathematics" (Pierce et al., 2007), which builds upon self-efficacy as defined by Bandura (1977). To affective engagement, we assign the meaning found in Pierce et al. (2007), i.e. "how students feel about the subject". Finally, we define mathematics value as it was defined in the framework proposed by Hannula (2002), i.e. "the value of mathematics-related goals in the student's global goal structure."

Apart from mathematics as a subject, we have also considered mathematics learning and instruction. Therefore, we have also investigated preferences for mathematics teaching and learning environments. We have adopted the scale for measuring such preferences proposed by Tait et al. (Tait, Entwistle & McCune, 1998; Tait & Entwistle, 1996). This scale is based on the approaches to studying introduced by Marton and Säljö (1984) and descriptions on strategic approaches to studying by Entwistle and Ramsden (1983). This questionnaire contains three scales: one on conceptions of learning with six items, one on approaches to studying with fifty-two items, and one on preferences for different types of course and teaching with eight items. In this study, we used the third scale, since the three scales are developed to be used independently. In this scale, items are evaluated according to the following categories: 5 = definitely like, 4 = like to some extent, 3 = unsure, 2 = dislike to some extent, and 1 = definitely dislike. By analysing students' responses on this scale, we aimed at discovering whether students favour mathematics teaching and learning environments that support understanding and are related to a deep approach to learning or environments that transmit information and are related to a surface approach to learning. A deep approach to learning has been associated with intention to seek meaning, relate ideas, and use evidence, and with interest in ideas. On the other hand, the surface approach to learning has been associated with lack of understanding, lack of purpose, syllabus-adherence, and fear of failure (Tait et al., 1998).

In order to better conceptualize the variables examined in this article, we developed a model to represent the connection between attitude

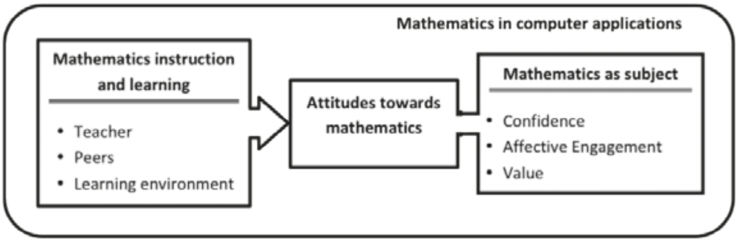

Figure 1. *Model of relationship between determinants of attitude towards mathematics*

towards mathematics as a subject and the attitude towards mathematics instruction and learning (figure 1). The model builds upon the model representing the relationship between attitude towards mathematics and other classroom variables as introduced by Haladyna et. al (1983). In our case, the study of attitude takes place in and is framed by the context of mathematics for computer applications.

Attitudes are often measured using self-reports (Reed et al., 2010). Our study also employs self-reports to address questions regarding attitudes and preferences regarding mathematics teaching and learning. However, we are aware that there can be substantial differences between self-reported and observed behaviours (King & Bruner, 2000; Veenman, Prins & Verheij, 2003). We have therefore conducted interviews and observations on a small number of students while they were working with mathematical problems. By combining these two approaches, we aimed at to get a deeper understanding and more reliable results (Borrego, Douglas & Amelink, 2009).

Context of the study

In order to answer the aforementioned research questions, we conducted a study employing both qualitative and quantitative methods. The study was carried out in the Media technology program of Aalborg university in two academic years commencing 2013 and 2014. The Aalborg university is unique in a Danish context because it has a portfolio of transdisciplinary educational programs where the division between the "creative" designer or architect and the "scientific" engineer is increasingly challenged and transcended. The program in Media technology is one example of such an educational program. In the following section, we present the Media technology program and we refer to the mathematics taught in this program and its applications in various subjects of the Media technology curriculum.

The Media technology program of Aalborg university

The Media technology program at Aalborg university is a program resting on the same fundamentals as information technology (i.e., mathematics, electronics, computer science) with a focus on media technologies such as audio, video, voice, image, film and multimedia. These media technologies are also seen from the user perspective, therefore human-computer interaction, interaction design, psychology and related fields are also important. Thus, Media technology is an educational program that focuses on research and development, which combines technology and arts and looks at the technology behind areas such as advanced computer graphics, games, electronic music, animations, interactive art and entertainment, to name a few.

In order to better explain the trans-disciplinary character of the Media technology program, we describe parts of the curriculum supporting different scientific fields (engineering, arts and humanities). During the span of the Media technology program, students are given a strong technical foundation, both in theory and in practice. The curriculum includes five programming courses, which cover the following areas: image processing, audio synthesis, computer graphics, and artificial intelligence. In these courses, students learn different programming languages depending on the area, (e.g. Processing, Java, C++, C#, CG) and they are given real-world projects to implement. The artistic dimension of the program is expressed by courses such as ”Audio-visual sketching, ”Audio processing”, ”Rendering and animation techniques”, which aim at teaching the students theories and techniques for artistic expression in various forms. The humanistic field is supported by courses such as ”Interaction design”, ”Human senses and perception”, ”Screen media”, ”Ethnographically informed design”, and ”Theory and practice of game design and development”, which aim at provide the students with knowledge on how humans perceive their surroundings (including media) and how to perform experiments using this knowledge.

During their second semester, Media technology students attend the ”Mathematics for multimedia applications” (MMA) course, which reviews topics from upper secondary mathematics that are relevant for the study. This course is taught by mathematics faculty, who is supported by two teaching assistants from Media technology. We present the topics taught and their applications to different courses of the program (technical, artistic, and humanistic oriented) in table 1. The mathematics course is quite intensive, covering various topics during only one semester. Therefore, the teacher has put effort in including in his teaching material only the important parts of each topic and mostly the ones that are relevant to Media technology. Students participating in this course have to submit an assignment after each lecture and four mini-projects. The mini-projects are submitted at the end of every thematic session (i.e. trigonometric functions and sound, numerical integration, systems of linear equations, and linear transformations and computer graphics).

Methods employed

In order to get insight in student attitudes and behaviours during the process of mathematics learning in this program, we have been gathering data during three semesters (figure 2). During the first semester of

Table 1. *The mathematical topics taught in Media technology and courses where these topics are needed.*

Topics in mathematics	Courses in Media technology curriculum
Review of trigonometry – measurement of angles, trigonometric functions and identities	Audio Processing (AP), Computer Graphics Rendering (CGR), Computer Graphics Programming (CGP)
The derivative – definition of the derivative, differentiation rules, rates of change	AP, Design and Analysis of Experiments (DAE)
Derivatives of trigonometric functions	AP
Exponential and logarithmic functions – definition, laws, differentiation	AP, DAE
Areas, sums, and integrals – area under graphs, Riemann sums, evaluation and properties of integrals	AP, DAE, CGR
Vectors in 2D/3D – length and addition	CGR, CGP
Dot and cross product – definition and properties	CGR, CGP
Lines and planes in space – parametric equations, intersection of lines/planes, angles between planes	CGR, CGP
Curves and motion in space – parametric equations, vector functions and their differentiation, velocity and acceleration, motion of projectiles	CGR, CGP
Matrices and vectors – definition of matrices, vectors as matrices	Image Processing (IP), CGR, CGP
Linear combinations, matrix-vector products, and identity/rotation matrices	IP, CGR, CGP
Systems of linear equations – augmented matrix, Gaussian elimination	IP, Physical Interface Design, CGR, CGP
Matrix multiplication and inversion	IP, CGR, CGP
Linear transformations and matrices	IP, CGR, CGP

our study, we gathered data in the MMA course by ethnographic observations of and interviews with students. The MMA course is chronologically the first mathematics course in the Media technology curriculum, and is taught during the second semester of the bachelor study by faculty in mathematics. During the second semester of the study, we distributed a survey to fifth semester bachelor students attending a mathematics workshop, which was organized as a preparation for the CGR and CGP courses. During the third semester of our study, we distributed an updated survey to students in fourth semester of bachelor attending a math workshop before the ”Design and analysis of experiments” and "Sound and music computing" courses began. We chose students in the aforementioned semesters, because these semesters contain the most mathematics-related courses.

During observations, seven ($n = 7$) second semester bachelor students, three females and five males aged 19 to 27 years old, served as individual cases. There is evidence in the literature (Onwuegbuzie & Leech, 2007) that this number of individuals is sufficient for obtaining insights of process-related phenomena. The seven students formed one study group and were attending the MMA course in their second semester (spring 2013). The students participated in the study voluntarily and the time span of the observations was four months (February until June 2013). We observed students during their allocated exercise time, which followed every lecture of the MMA course. During these observations, we focused on how students approached mathematical problem solving and how they cooperated with each other. We used observation guides in order to gather observational data. Moreover, we had a short discussion after every exercise section, where students were asked to comment upon the problem solving process they had just finished, and their feelings about it. At the end of the semester, we had a focus group interview with all seven students, where we asked them to reflect on their experience during this course, challenges they faced, and how they perceive mathematics in their studies. We also asked to propose ways to improve mathematics teaching and learning in the Media technology educational program. The interviews were carried out in a semi-structured way and were video recorded and transcribed. When we refer to the students, we use pseudonyms to ensure anonymity. These students (except from one male student who dropped out in the end of the second semester) took also part in our study as fourth semester students (spring 2014).

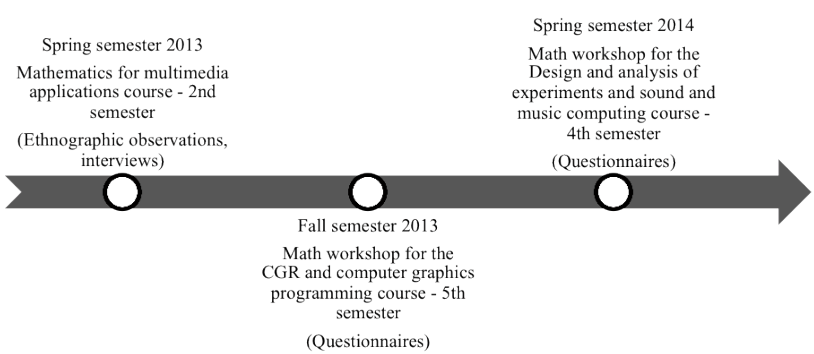

Figure 2. *Timeline – 5th semester survey took place before 4th semester one*

Student attitudes towards mathematics and self-reported behaviours were also collected using questionnaires. Questionnaire items were derived from existing measurement instruments for these constructs, namely the *Mathematics and technology attitudes scale* by Pierce et al. (2007) and scale developed by Barber and Houssart (2011). We will refer to the questionnaire distributed in the fifth semester as AQ5 (Attitude questionnaire semester 5) and we will refer to the one distributed in the fourth semester as AQ4 (Attitude questionnaire semester 4). Both questionnaires used a Likert scale. Items in this scale were measured using 5-point rating scales, with the range of answers from ”strongly disagree” to ”strongly agree.” The two questionnaires were not identical, because we decided to make adjustments in the items after we collected data with the AQ5. In AQ5, we also added the items regarding preferences for learning and teaching environments from the *Approaches and study skills inventory for students* (Tait & Entwistle, 1996). In fall 2013, we distributed the AQ5 to 80 students and collected responses from 69 Media technology students ($n = 69$) (response rate of 86.2 %). In spring 2014, we distributed the AQ4 to 129 students and collected responses from 106 students ($n = 106$) (response rate of 81.2 %).

Results

In this section, we firstly present data on student attitudes towards mathematics as a subject and then we cite student preferences on teaching and learning approaches in mathematics.

Attitudes towards mathematics as a subject

The results of AQ5 and AQ4 are shown in table 6 and table 7 respectively (see appendix [1]). These results indicate that mathematics taught or refreshed in Media technology is not popular among Media technology students (only 23 % of fifth semester students strongly agreed or agreed that math was one of their favourite subjects) and is also considered to be a difficult subject (only 11 % of fourth semester students rejected the assertion that mathematics is difficult). However, 46 % of fifth semester Media technology students find mathematics interesting, while the majority in both semesters is aware that mathematics is useful in their study and in real life. More specifically, 78 % of fifth semester and 87 % of fourth semester students agreed or strongly agreed with the statement ”I need mathematics for my studies”, and 68 % of AQ5 and 88 % of AQ4 acknowledged that mathematics is useful in real life. Furthermore, 88 % of Media technology students in fourth semester admitted that they get a sense of satisfaction when they solve mathematics problems, while 48 % enjoy doing mathematics.

Regarding math confidence, 62 % of students in the fourth semester and 40 % of the students in fifth semester believe that they can get good results in mathematics. In AQ4, we included additional questions related to mathematics confidence (table 3). 43 % of students believe that they have a mathematical mind, and 36 % that they are good at mathematics. Moreover, 51 % of students believe that they can handle difficulties in mathematics. For the questions addressing mathematics confidence, the percentages of neutral answers are high (30–41 %).

Attitudes and behaviours from observational and interview data

Since six out of the seven case students took also part in our study as fourth semester students, we were able to compare their responses ($n = 6$) to the attitude (AQ4) and preferences questionnaire with their observed attitudes throughout their second semester. In order to do that, we went through our observational and interview data and isolated statements or behaviours related to mathematics confidence, affective engagement, and mathematics value. Regarding mathematics confidence, four of the case students (Sarah, Ellie, Anton and Stefan) did not consider themselves good at mathematics and questioned their ability to handle difficulties in this subject in the beginning of the semester. The other three students (Liz, Bryan and Sean) exhibited high confidence in their mathematical skills and reported that they were also good at mathematics at high school. Bryan had also attended a high school with specialization in mathematics and kept calling himself a ”mathematics genius”. The three of them were also confident that they would achieve good results in this course. However in the beginning of the semester, all of them reported that they did not remember a lot from the mathematics they had at high school and this applied especially to the older students. Throughout the semester, confident case students exhibited higher confidence, as they worked with mathematical exercises and they started recalling what they had already learnt. The same applied for Sarah. Ellie, Anton and Stefan did not participate in the problem solving during any of the exercise sessions, even when present in the session. At the end of the semester, Liz, Bryan, and Sean passed the course with an A+, Ellie and Sarah passed obtaining a grade A, Anton failed the course exam (lowest passing grade was D), and Stefan dropped out. The six remaining case students participated in our study one semester after observational data was gathered. An overview of the responses on the attitude questionnaire (AQ4) of the six cases is presented in table 2. The responses concerning self-reported attitudes (questions 6–10 in AQ4) are consisted with our own observations, since the mean value of Sarah's, Anton's, and Ellie's scores in the questions regarding self-efficacy and achievement in mathematics are the lowest among the case students.

Table 2. *Responses by individual cases on attitude questionnaire AQ4*

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Sarah	4	4	4	4	4	3	3	3	3	3	5
Bryan	4	5	4	5	5	5	5	4	4	4	3
Sean	4	4	4	5	5	4	3	4	4	4	3
Liz	3	4	5	4	4	5	5	5	5	5	2
Ellie	4	4	3	4	4	4	4	4	4	3	3
Anton	3	4	3	5	4	4	2	4	1	2	4

Notes. Qn refers to the nth question in table 7, 1 = strongly disagree, 5 = strongly agree

In regard to affective engagement, all case students exhibited feelings of anxiety at the beginning of the semester. However, the confident students (Sean, Bryan, and Liz) did not consider mathematics to be a difficult subject and throughout the semester they discarded their anxiety and reported feelings of satisfaction because their problem solving skills improved. Moreover, they mentioned that they enjoyed working with mathematical problems, even when they felt they were challenging. Although Sarah also improved, she continued to feel anxious and to consider mathematics being a challenging subject. Ellie, Anton and Stefan went to a state of apathy throughout the semester, although Ellie continued submitting the required hand-ins for the course. However, she stated that she completed these assignments at home because she preferred to work alone. The responses concerning self-reported affective engagement (questions 1–3 and 11 in AQ4) are in general consisted with our own observations. Ellie has mainly neutral answers and Anton and Sarah still reported mathematics to be difficult. However, they reported having positive feelings during mathematical problem solving.

As far as mathematics value is concerned, all case students stated throughout the semester that they were missing the application aspects of the mathematics they were working with. Especially, they were missing the applications in the specific study and they were asking for concrete examples. The course teacher provided a few examples during lectures and two of the mini-projects had a study-related subject (sinusoids for audio processing and linear transformations for computer graphics). However, students still felt that they were missing the connections between mathematical topics and topics in Media technology.

Regarding mathematics in real life, students acknowledged that mathematics can be applied and be helpful in many aspects of their everyday life (they reported examples of e.g. getting a student loan, predicting and calculating monthly expenses). Looking at their responses regarding mathematics value one semester later (questions 5 and 6 in table 2), we can see that students had positive to very positive answers regarding mathematics value both in their studies and in real life.

Preferences for teaching and learning environments in mathematics

In AQ5, there was an additional part regarding preferences for different types of course and teaching of mathematics. In this part, we wanted to investigate whether fifth semester Media technology students prefer teaching supporting understanding (related to a deep study approach) or teaching transmitting information (related to a surface study approach), as defined by Entwistle, Tait and McCune (2000). There were four items that were associated with a deep approach (table 3), and four items associated with a surface approach (table 4). As proposed by Entwistle et al., scores on the two approaches were created by adding together the responses on the items, which contributed to each approach. The results showed that the surface approach scores higher (table 4) than the deep approach (table 3) among Media technology students. The students favoured especially courses with clear guidelines of what they have to read and books or teaching materials, which give definite facts and easy to learn information.

The AQ4 contained also a part investigating learning preferences. This part consisted of 6 sub-scales, which can be seen in table 8 (see appendix[1]). In this part, we aimed at investigating which mathematics learning approaches are considered optimal by Media technology

Table 3. *Statistics on items for preferences for teaching supporting understanding (related to a deep approach) in fifth semester (AQ5)*

	Mean	Std. Dev.	*n*
I like lecturers who encourage us to think for ourselves and show us how they themselves think.	3.737	.9548	69
I like exams which allow me to show that I've thought about the course material for myself.	3.316	.9665	69
I like courses where we're encouraged to read around the subject a lot for ourselves.	2.825	1.1200	69
I like books which challenge you and provide explanations which go beyond the lectures.	3.386	1.0816	69
Sum of the four items	13.2	3.1	4

students. As shown in table 8[1], fourth semester Media technology students favoured "working through questions on their own" (66 %), and "discussing problems or questions with friends" (58 %). The least popular options were "ask the teacher for help in lessons" (35 %), and "listening to a clear explanation from the teacher" (39 %). These percentages are derived by adding the "strongly agree" and "agree" responses.

Preferences for teaching and learning environments from observational and interview data

Since the Aalborg university applies a problem-based learning approach combined with group work (Kolmos, 1996), students are introduced and used to the culture of working in groups for their course and project work. However, exercise sessions in MMA do not have to be group work sessions. Our observations revealed that the case students chose to work together during these sessions, apart from Ellie and Anton, who were present in these sessions but did not participate in the problem solving process. Stefan worked most of the times together with the other students, when he was present. Moreover, students formed smaller groups while studying, which were mostly constant in their composition: Sarah and Liz worked together, Sean and Bryan formed another pair and Stefan joined them when he was present. Anton worked with both subgroups, when he was active. Moreover, we have observed many cases, where students tried to explain challenging aspects to the other group members and they corrected each other.

In the AQ4 questionnaire, Ellie favored working on her own and reading worked examples, which is in line with our observations. Anton favored only the role of the teacher in learning, which also is consisted with his behavior during observations. However, Liz reported preference

Table 4. *Statistics on items for preferences for teaching transmitting information (related to a surface approach) in fifth semester (AQ5)*

	Mean	Std. Dev.	*n*
I like lecturers who tell us exactly what to put down in our notes.	3.754	1.1225	69
I like exams or tests which need only the material provided in our lecture notes.	3.789	1.0477	69
I like courses in which it's made very clear just which books we have to read.	4.263	.8351	69
I like books which give you definite facts and information which can easily be learned.	4.333	.6075	69
Sum of the four items	16.2	2.1	4

on working alone and reading examples, which is not consisted with her exhibited behavior in the second semester.

Regarding teaching of mathematics, students reported during interviews that they would like to be able to participate more actively during lectures in mathematics, since the MMA lectures took place based on the traditional transmission model. We also observed that they also stopped following lectures of MMA after the first one and a half month and they chose to study the course material and solve the exercises by themselves. An overview of the responses on preferences for teaching and learning of the six cases is presented in table 5 (responses obtained during their 4th semester).

Table 5. *Responses by individual cases on preferences for teaching and learning*

	Q1	Q2	Q3	Q4	Q5	Q6
Sarah	4	4	4	4	4	4
Bryan	2	4	4	4	3	3
Sean	4	4	4	4	4	4
Liz	3	3	4	2	1	4
Ellie	4	3	5	2	2	5
Anton	5	2	3	3	4	3

Note. Qn refers to the nth question in table 8, 1 = strongly disagree, 5 = strongly agree.

Discussion of results

Our results indicate that Media technology students realize the importance of mathematics, since they consider mathematics to be interesting and essential for their studies. Our results showed also that Media technology students acknowledge the importance of mathematics in real life. In the questions regarding value, students gave the highest positive responses among all. Moreover, the individual cases mentioned the necessity for mathematics education in such trans-disciplinary studies to include application aspects, in order to increase motivation among students. This is a confirmation of what have already been mentioned in the literature related to mathematical education of other engineers (Bingolbali et al., 2007; Maull & Berry, 2000). Therefore, the mathematics curriculum in such studies should emphasize applications aspects and connect mathematical topics with study-specific topics.

The Media technology students acknowledged a sense of satisfaction when solving mathematical problems and they stated that they enjoy doing mathematics to some extent. Moreover, they admitted that in mathematics they get rewarded for their efforts. However, the students did not favour mathematics over other courses and considered it to be difficult. These findings contribute to the conclusion that Media technology students do not possess strong affective engagement in mathematics. This conclusion is also supported by our observations, which indicated that four case students exhibited mathematics anxiety in the beginning of the semester. The feeling of anxiety was replaced by apathy for three of them, and it is probable that it contributed to two of them failing to complete the MMA course. Mathematics anxiety has been found to hinder learning processes and performance (Townsend, Moore, Tuck & Wilton, 1998), and to affect working memory (Hopko et al., 1998). We suggest therefore that teachers in Media technology focus more on how to help students overcome such feelings.

As far as math confidence is concerned, our results show that Media technology students tend to be confident and to consider themselves effective in mathematics in general (percentages of ”strongly agree” or ”agree” outnumber those of ”strongly disagree” or ”disagree”). However, the high percentages of neutral answers (”neither agree nor disagree”) indicate that these students do not have a strong opinion on confidence and self-efficacy in mathematics. In the fourth semester, percentages of ”strongly agree” or ”agree” are higher than those in the fifth semester but since the questionnaires administered were not exactly the same, we cannot draw any firm conclusions based on this difference.

Our qualitative data indicates that more competent students tend to be more confident. On the other hand, the cases of Anton and Stephan show that low confident students may be more inclined to fail or even drop out. Moreover, the cases of Ellie and Sarah indicate that students may exhibit low confidence despite achieving good results. Since mathematics confidence has been found to contribute to the effectiveness of learning processes (Pierce et al., 2007), we believe that it is imperative that lectures and activities are designed with the aim to increase mathematics confidence among Media technology students throughout the entire study.

Regarding mathematics instruction, Media technology students expressed preferences in teaching that transmits information and syllabus-bound focus on minimum requirements. This provides some indication that these students might not intend to gain deep understanding in mathematics, although they admit that it is an interesting and essential subject. Moreover, students favoured collaborative learning over explanations and help from the teacher. This preference could be attributed to the local context, since Aalborg university applies project-based learning combined with group work in all its programs. According to PBL, students shall be responsible for their own learning while working in groups, while the teacher is the facilitator of this learning process rather than the instructor. Therefore, students may not expect their teachers to provide solutions or explanations but rather guide them to find the solution by their own. Finally, the case students had different opinions on learning environments and we observed that introvert students favoured studying alone and reading worked examples or consulting the teacher. Nevertheless, the case of Liz is inconsistent with this finding. Liz reported that she prefers to study alone, which contradicts her exhibited behaviour. We attribute this inconsistency to well-known fact that reported and exhibited behaviours may differ.

A possible explanation for the aforementioned findings on preferences for teaching and learning environments can be attributed to the fact that the students participating in our study belong to the Millennial generation (Atkinson, 2004; Howe & Strauss, 2007). More precisely, behaviours such as preferences for breadth- over depth learning, being team oriented and more comfortable with peer learning than learning with teachers, impatience and less reading have been found to characterize students born between 1982 and 2002, i.e. Millennial generation students (Dumais, 2009; Much, Wagener, Breitkreutz & Hellenbrand, 2014). Therefore, future research regarding these students should draw on findings and suggestions about this generation found in literature.

However, we would like to acknowledge that the questionnaire on preferences asked students to choose the best learning and instruction method according to their opinion. Therefore, student responses show a tendency, and they can be used to compare the different methods but they cannot be used to argue that students do not favour other methods at all. Moreover, students' self-conceptions on how they learn best should be problematized. Research has shown that it can be hard for students to evaluate their own learning according to learning goals since the learning goals set by the teacher are not always adopted by the students (Boekaerts & Corno, 2005; Neuman & Hemmi, 2012).

Conclusion

The present study provides some intriguing insights into student attitudes towards mathematics and preferences for teaching and learning in mathematics. The study was carried out in Media technology at Aalborg university, a trans-disciplinary engineering educational program. The findings indicate patterns which support previous research in the area of mathematics attitudes and preferences of engineering students while at the same time bringing forth worthwhile new avenues for further investigation.

The findings of our study offer some implications for mathematics teaching of Media technology students, which future efforts should take into account. In the literature, there is agreement that engineering students need to know and to learn mathematics (B. Morgan, 2011). Our study also pointed out that Media technology students acknowledge the importance of mathematics. Nevertheless, the way to teach mathematics might need to be revised. We argue that our findings regarding Media technology students' mathematics attitudes and their implications for mathematics education in Media technology provide valuable insights for trans-disciplinary engineering studies and more art-minded engineering students in a Danish context.

The challenge for the future is to build a mathematics curriculum for such engineering disciplines in a way that takes students' mathematical needs, expectations and aspirations into account. But this challenge requires the continuous adjustment of the form and content of the courses, in order to meet the interests of students, as well as research documenting the effects of such initiatives. If these conditions are met, then there is potential to increase mathematics confidence and decrease anxiety among such students.

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Note

1 The appendix containing table 6, 7 and 8 are published on the Nomad website, ncm.gu.se/nomad

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