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Teaching Computer Science with Animation: Attitudes and Ways of Experiencing

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עבודה זו מוקדשת להורי, ברוריה וחיים, ולבני, עומר, האהובים

שתמכו, עודדו, כאבו ושמחו עימי בכל שלב.

This work is dedicated to my parents,
Bruria and Haim, and to my son, Omer

Who supported, encouraged, suffered
and shared my happiness in every step.

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ABSTRACT

Animation systems—software tools that can show a dynamic view of the execution of a program—were designed to help computer science (CS) novices improve their understanding and to help teachers facilitate learning. Preliminary studies on the effectiveness of animation systems on the understanding of students have shown encouraging results. Nevertheless, the use of animation systems is not very widespread. In order to understand the anomaly between the encouraging results that the use of animation systems has on students and the fact that teachers do not use them I conducted my study.

The animation system that was used in this study was Jeliot. This tool was developed specifically for novices. This system is used for more than a decade now and has been improved over the time as a result of research on the effect that this animation system has on students. Studies show positive results on the effect that Jeliot has on the understanding of CS topic by students.

I raised two research questions: (1) What are the qualitatively different ways that teachers experience the use of an animation system as a pedagogical tool? (2) What are the attitudes that teachers have towards the use of an animation system, especially those who use the animation rarely or not at all?

The study presented here shows the results of a three-phase research project: (1) a phenomenographic study designed to describe the different ways that teachers experience the use of an animation system as a pedagogical tool; (2) a study of the attitudes that teachers possess on the use of the Jeliot animation system as a pedagogical tool—according to the theory of planned behavior (TPB); (3) an analysis based on a combined methodology of the first two methodologies.

The result of the phenomenographic phase is an outcome space of four different ways (categories) that computer science (CS) teachers experience the use of an animation system as a pedagogical tool. These four different ways include two positive ways (Appropriation and By-the-book) and two negative ones (Repudiation and Dissonant). The outcome space is ordered in a hierarchical order. The Appropriation way of experiencing is the most desired way. This teacher uses the animation system routinely in class, chooses the most appropriate option in Jeliot for the topic he or she has to teach, the teacher develops novel ways to use

Jeliot. The By-the-book way of experiencing is the second in the hierarchy; a teacher in this category employs Jeliot in a canonical way, as taught in the course. The Repudiation category represents the teachers who see no pedagogical value in using an animation system; these teachers usually are very vocal and express their rejection explicitly. These teachers do not use Jeliot at all in their classes. The category at the bottom of the hierarchy is Dissonant. Teachers who experience the use of Jeliot in this way are very silent. They experience the use of Jeliot in a combined way—positive and negative—in the same context; The Dissonant teachers show enthusiasm towards the use of Jeliot, but they rarely use it in class.

The results of the phenomenographic phase relate to populations and not to individuals. But, I found that the reluctance to use Jeliot appears very close to the time teachers are exposed to the tool for the first time, Therefore, I decided to study the negative ways of experiencing, in particular, the connection between the attitudes that teachers possess towards the use of Jeliot as a pedagogical tool and the behavior of rejecting it. This phase deals with the second research question and uses the TPB methodology.

The results show that CS teachers, in general, are in favor of using technological tools in their classrooms. One of the most striking results shows that in spite of the fact that computer science teachers have positive behavioral beliefs about the use of animation systems in their classrooms, most of them feel a low level of *perceived behavior control* (PBC). This means that issues like control of the tool and of the class are very crucial for CS teachers. It appears that one of the most important characteristics of Jeliot—its explanations—bother many teachers. They are afraid to lose their central role in class, many of them perceive themselves as the Authority in class, and they do not need any kind of help. This low score of PBC may explain the low use of animation systems.

The third phase of the study connected between the results of the first two phases. The idea was to build profiles for each of the ways of experiencing I found at the first phase, based on the TPB predictors. In this way an educator can predict that a teacher will have negative attitudes and approach the teacher with an appropriate intervention. I found that the Dissonant group of teachers can be divided into two subgroups: one who used Jeliot (Dis1) and the other one who rarely did so (Dis2). I went back to the phenomenogrpahic interviews and re-read the interviews of those teachers. I found that the difference between the groups was in the fact that the teachers from Dis1 did not participate in a course on Jeliot while the other subgroup did. I concluded that this shows the importance of a course on animation system, specifically addressing problems of controlling the system.

The results suggest that increased acceptance of such tools by teachers depends on integrating the tools with other learning materials and on addressing the role of the teacher in the use of software by the students. I conclude that developers and educators should give attention to control issues relevant to the tools they develop and use.

תקציר

סביבות אנימציה—כלי תוכנה המציגים באופן דינאמי הרצה של תוכנית—תוכננו כדי לעזור לתלמידים מתחילים לשפר את הבנתם של מושגים במדעי המחשב ולהקל על המורים בתהליך ההוראה. מחקרים קודמים על ההשפעה של סביבות אנימציה על ההבנה של תלמידים הראו תוצאות מעודדות. למרות זאת, השימוש בסביבות אנימציה מצומצם. כדי להבין את האנומליה שבין התוצאות המעודדות שיש לסביבות האנימציה על התלמידים לבין העובדה שמורים לא משתמשים בהן ערכתי את מחקרי.

סביבת האנימציה בה השתמשתי במחקר זה היתה Jeliot. כלי זה פותח במיוחד לתלמידים מתחילים. הסביבה בשימוש יותר מעשור ועוברת תהליך של שיפור במהלך השנים. שיפור זה הוא תוצאה של מחקרים על השפעת סביבת אנימציה זו על תלמידים. מחקרים הראו תוצאות חיוביות על ההשפעה שיש ל-Jeliot על ההבנה של מושגים במדעי המחשב על-ידי תלמידים.

העליתי שתי שאלות מחקר: (1) מהן הדרכים השונות בהן מורים חווים את השימוש בסביבת אנימציה ככלי עזר להוראה? (2) מהן עמדות המורים כלפי השימוש בסביבת אנימציה, במיוחד אלה שממעטים להשתמש בה או אינם משתמשים בה כלל?

המחקר המוצג כאן מראה תוצאות של פרוייקט מחקרי בעל שלושה שלבים: (1) מחקר פנומנוגרפי (Phenomenography) שבוצע כדי לתאר את הדרכים השונות בהן המורים חווים את השימוש בסביבת אנימציה ככלי עזר להוראה; (2) מחקר על העמדות של מורים כלפי השימוש ב-Jeliot ככלי עזר להוראה—לפי המתודולוגיה-Theory of Planned Behavior (TPB); (3) ניתוח המבוסס על מתודולוגיה המשלבת את שתי שיטות המחקר הקודמות.

תוצאת המחקר הפנומנוגרפי הוא מרחב המכיל ארבע דרכים שונות (קטגוריות) שמורים למדעי המחשב חווים את השימוש בסביבת אנימציה ככלי עזר להוראה. ארבע דרכים אלה כוללות שתי דרכים חיוביות (Appropriation ו- By-the-book) ושתי דרכים שליליות (Repudiation ו- Dissonant). מרחב תוצאות זה מסודר באופן היררכי. חווית ה-Appropriation היא הרצויה ביותר. מורה החווה בדרך זו משתמש/משתמשת בסביבת האנימציה באופן שגרתי בכיתה, בוחר/בוחרת את האופציות המתאימות ביותר ב-Jeliot לצורך הוראה של נושא מסויים, ומפתח/מפתחת דרכים חדשות לשימוש ב-Jeliot. חווית ה-By-the-book היא השנייה בסדר ההיררכי; מורה בקטגוריה זו משתמש/משתמשת ב-Jeliot בדרך אחת ויחידה, כפי שלמד/למדה בקורס. קטגורית ה-Repudiation מייצגת את המורים מוצאים את השימוש בסביבת אנימציה כנטול ערך פדגוגי; מורים אלה קולם נשמע מאד והם מבטאים את התנגדותם במפורש. מורים אלה אינם משתמשים ב-Jeliot כלל. הקטגוריה ברמה הנמוכה ביותר בהיררכיה היא Dissonant. מורים שחווים את השימוש בסביבת האנימציה בדרך זו הם שקטים מאד. הם חווים את השימוש

ב-Jeliot בדרך משולבת— חיובית ושלילית—באותו קונטקסט; מורים אלה מראים התלהבות לגבי השימוש ב-Jeliot, אך ממעטים מאד להשתמש בו בכיתה.

תוצאות המחקר הפנומנוגרפי מתייחסות לאוכלוסיות ולא ליחידים. אבל, מצאתי כי ההתנגדות לשימוש ב-Jeliot מופיעה בסמוך לזמן בו המורים נחשפים לראשונה לסביבה, לכן, החלטתי לבחון את דרכי החוויה השליליות, למעשה, את הקשר בין עמדות המורים לגבי השימוש ב-Jeliot ככלי עזר להוראה לבין ההתנהגות שהיא ההתנגדות לסביבה. שלב זה במחקר עוסק בשאלת המחקר השנייה ומשתמש במתודולוגיה TPB.

התוצאות מראות כי המורים למדעי המחשב, באופן כללי, הם בעד השימוש בכלים טכנולוגיים בכיתותיהם. אחת התוצאות המפתיעות ביותר היתה שלמרות העמדות החיוביות שהמורים מפגינים כלפי השימוש בסביבת האנימציה בכיתותיהם, לרובם יש רמה נמוכה של perceived behavior control (PBC). זאת אומרת שנושאים כמו שליטה בכלי ובכיתה חשובים מאד למורים למדעי המחשב. מתברר כי התכונה החשובה ביותר של Jeliot—ההסברים שהוא מספק— מטרידה מאד את המורים. הם מפחדים לאבד את תפקידם המרכזי בכיתה, רבים מהם מעריכים את עצמם כבעלי הסמכות (Authority) בכיתה, והם אינם זקוקים לעזרה. הציון הנמוך של PBC יכול להסביר את השימוש המועט בסביבות אנימציה.

השלב השלישי במחקר חיבר בין התוצאות של שני השלבים הראשונים. הרעיון היה לבנות פרופילים לכל אחת מהדרכים השונות לחוות את השימוש ב-Jeliot שמצאתי בשלב הראשון, על-פי המשתנים המנבאים של ה-TPB. בדרך זו מדריך בקורס יכול לחזות מראש כי מורה מסויים/מסויימת יהיה/תהיה בעל/בעלת עמדות שליליות ובהתאם לכך המדריך יכול לתכנן התערבות מתאימה למורה זה/זו. מצאתי כי קבוצת ה-Dissonant מתחלקת לשתי תת-קבוצות של מורים: אחת שהשתמשה ב-Jeliot (Dis1) ושנייה שכמעט ולא השתמשה (Dis2). חזרתי לראיונות הפנומנוגרפיים של מורים אלה וקראתי אותם בשנית. מצאתי כי ההבדל בין שתי הקבוצות היה נעוץ בעובדה כי המורים מ-Dis1 לא השתתפו בקורס על Jeliot בעוד שהמורים מהקבוצה השנייה השתתפו בו. הסקתי כי זה מראה על חשיבות הקורס על סביבת אנימציה, במיוחד ההדגשה על בעיות של שליטה בכלי.

התוצאות מראות כי עלייה בשימוש בכלי תלוייה בשילוב הכלי בחומרי הלמידה ובטיפול בנושא תפקיד המורה המשתמש בסביבה ככלי עזר להוראה. אני ממליצה למפתחי הסביבות ולמדריכים בקורסים לשים דגש על בעיות שליטה רלוונטיות לכלים שהם מפתחים.

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1. INTRODUCTION

1.1 Rationale

Learning to program is hard and novice programmers suffer from a wide range of difficulties. du Boulay (1986, p. 58) defined the *notional machine*—a model of the computer as it executes programs—and claimed that it takes quite a long time to learn the relationship between the static representation of a program on the page and its dynamic execution on the notional machine. Animation systems—educational software tools that show a dynamic view of the execution of a program—can help novices improve their learning of programming and facilitate teaching. However, the use of such visualization tools is not as widespread as one would expect.

In their meta-study, Hundhausen, Douglas and Stasko (2002) suggested that it is not enough to have a nice visualization tool; its effectiveness depends on how it is used (p. 284). Hundhausen (1997) defined *system roulette* as the situation where visualization systems are *orphans*, since their developers did not deal with the real needs of their potential users (p. 2). This led me to conclude that studying just the use of an animation tool in class is not enough and that it is very important to study what teachers need, since they are the ones who decide if and how the tool is used. A similar claim can be found in a recent paper by Lönnberg and Berglund (2007).

I believe that teachers are the connecting link between the animation system and the students. *The teachers' point of view towards using animation as part of the teaching process has never been studied*. In order to understand the teachers' point of view, I used the phenomenographic framework to find the different ways that teachers experience the use of an animation system as a pedagogical tool. The hierarchical organization of the outcome space that is a result of the data analysis of the phenomenographic research style will help teachers reflect on methods of teaching with an animation system and improve those methods. Such a study can also help researchers and developers gain additional perspectives on what is really needed from an animation system.

Computer science teachers are different from others in the teaching community. This group contains teachers that use software and technology all the time; it is a part of their education and practice. Computers are an integral part of the Computer Science (CS) teachers' way of teaching, since at least some of their classes are located in the computer laboratory. *It is only logical to assume that CS teachers have the ability, the knowledge and the skills to operate computers and technology software, and the propensity to use them in the classroom.* But, as I said earlier, many CS teachers do not use animation systems, which are software tools designed to facilitate teaching CS concepts. This is in contradiction to the expectations of the innovators, since we have here a group of teachers who—in spite of their abilities (abilities that innovators believe that will help teachers use technology and computers in their classrooms)—do not use this software. Velázquez-Iturbide, Pareja-Flores, and Urquiza-Fuentes (2008) found that one of the most notable obstacles to the adoption of animation systems is the considerable effort that the use of them represents to the instructors. A study of the way CS teachers experience and perceive the use of an animation system as a pedagogical tool and the described behavior of the teachers may help innovators achieve higher rates of acceptance.

The result of the phenomenographic phase was an outcome space that described the qualitatively different ways that teachers experience the use of an animation system as a pedagogical tool. The outcome space consisted of two positive categories of using an animation system and two negative ones.

I was interested in understanding the behavior of the teachers who showed a negative way of experiencing in using an animation system, as I found in the first phase. The rationale for the second phase of my research was my belief that this understanding would help teachers, developers of animation systems for CS, and innovators of curricula in general. Such behavior has never been studied in the context of CS. The assumption is that CS teachers who are used to computers will employ them routinely, but it appears to be that not all software tools are used equally. This scenario might appear elsewhere and developers of curricula should take this behavior and its origins into consideration.

1.2 Research Questions

1. What are the qualitatively different ways that teachers experience the use of an animation system as a pedagogical tool? (How do they use the animation system? What are their reasons for not using an animation system?)
2. What are the attitudes that teachers have towards the use of an animation system, especially those who use the animation rarely or not at all?

The research was performed in three phases: the phenomenographic phase deals with the first research question; the second phase deals with the next research question this is the TPB phase. The third phase of the study made the connection between the first two phases.

1.3 The Research Story

1.3.1 The first phase - The phenomenographic phase

Initially I employed the "classical" phenomenographic method, in which the population consisted of a small number of subjects (group A) *within a single context.* The research population was high-school teachers of elementary computer science, and the context was the teachers' use of the Jeliot animation system as a pedagogical software tool during an entire school year. But as time went by I understood that some of the teachers did not use Jeliot as I expected them to do; I became aware that some teachers simply rejected the use Jeliot as a pedagogical tool. This was a surprise to me, because I had not considered the possibility that *these* teachers would not want to use Jeliot at all.

This discovery led me to go beyond the classical methodology of phenomenography, by extending the scope of the investigation beyond the original (small) population to teachers in large teacher-training courses (groups B and C). Although these large courses constitute a context different from the original one, I believe that this methodological extension is *consistent* with phenomenography, because a researcher can search for new sources as long as this leads to an increase in the variability that is observed:

> Widening the range of possibilities of experiencing a certain phenomenon is the most crucial element when it comes to learning about that phenomenon. There are different objects of experience and there are different ways of experiencing the same object of experience. While the former is not phenomenography (e.g. female stereotypes in Swedish film-melodrama of the 1930s) the latter is (e.g. different ways of apprehending children at a play in a certain setting). (Marton, 1997, No page numbers)

In my case, the object—the Jeliot animation system—remains the same, but the ways of experiencing it are increased.

Extensions of "classical" phenomenography have been used by other researchers. For example, Lister, Box, Morrison, Tenenberg & Westbrook (2004) used interviews and *books* as co-equal sources for a single research project! A book is certainly not a single context because it can be used in different ways by different instructors in different courses, and a book is certainly not an interview which is the classical tool of phenomenographers. Nevertheless, I believe that their extension of the methodology is acceptable.

The teacher-training courses were designed to introduce teachers of computer science to the Java programming language. In the first course (group B), the teachers were exposed to the animation system after studying basic concepts in Java. Many teachers were very vocal in their rejection of Jeliot; they said that they do not need the animation system to teach such easy material. Later, when they studied trees in Java, an advanced concept, I understood that the teachers did not grasp the concept of constructors in Java. When I used Jeliot to explain constructors, the teachers explicitly expressed the opinion that animation can significantly contribute to learning.

This led me to the awareness of *the importance of the context* in which teachers encounter Jeliot, so I widened the investigation to a group of teachers in another course on Java (group C). In the second course, Jeliot was shown to the teachers at the *beginning* of the course, just after studying constructors. The teachers showed enthusiasm towards the use of Jeliot for explanations in class, and said that it would help them save time since the students can see everything. Among these teachers were some who had been part of group A and had showed resistance to the use of Jeliot; it was these teachers who led me to the importance of the Dissonant category that will be discussed later.

The final group (group D) of teachers that I chose to investigate participated in a short course on Jeliot. (Because these teachers voluntarily participated in the course, it is reasonable to assume that they had an initial positive attitude toward the tool and this was taken into account in the analysis.) Since no new ways of experience were discovered in this group, I decided that the phenomenographic investigation had been completed.

Since each of the four groups of teachers formed a different context, I could "see" a wider spectrum of the ways that teachers experience the use of an animation system.

1.3.2 The second phase - The TPB phase

In the second phase, I used the theoretical framework of the *Theory of Planned Behavior (TPB)*, which is also a methodology. TPB is a quantitative research approach, but my population is not large enough, so I conducted a pilot study based upon TPB. This study contains all the necessary items for TPB, but is considered as a pilot study only (as every TPB research project must have (Ajzen, 2002b)). I constructed a questionnaire that was based on the data I collected from the first phase of my research. The questions were asked according to citations given by teachers who experienced the animation system in a negative way; this is the reason that a reader may find some of them expressed in a negative manner. In the phenomenographic part of my study, I investigated a population consisting of four groups, while for the TPB part, only the two groups A and D were used. They consisted of teachers who are well known to me so that I could justify the results from the analysis.

1.3.3 The third phase – Back-to-phenomenography

As a result of the TPB phase, I wanted to predict the behavior of teachers; when they are asked about using Jeliot as a pedagogical tool. In order to achieve this goal, I constructed a general characterization based on the TPB predictors—a *profile*—of each category I found in the phenomenographic phase. I was especially interested in the predicting the behavior of teachers that could belong to the Dissonant category. Predicting the behavior could serve developers of pedagogical software to predict if a teacher might be a Dissonant one and try to change their attitudes during a course that eventually leading to changing the behavior. I developed an algorithm for prediction and a model that can both predict the way of experiencing according to attitudes and explain how a change in the attitudes can cause a change in the behavior.

1.4 Contributions of the Thesis

1. This research provides a novel perspective on the problem of why teachers do not use software tools. It explicitly connects behavior (not using tools) to attitudes (about the tools and the teacher's position in the classroom) and this can be used to address the problem.

2. The study supplies empirical evidence of what researchers had felt intuitively about the categorization of the ways that teachers experience the use of software tools.

3. My research is the first empirical study of how CS teachers experience a pedagogical software tool. The results were unexpected because it was reasonable to assume that CS teachers are fully comfortable with routine use of software.

4. This study gives a voice to teachers who reject and repudiate the use of a pedagogical software tool, as opposed to most research which studies teachers who *accept* new technology.

5. I built a novel model that can be used to predict teachers' behavior in this context. The model is primarily based upon the way that teachers perceive their role in class, and can be used by innovators to facilitate the acceptance of software tools.

6. Developers of visualization tools can be guided by this research in order to learn about the needs of teachers and the ways to improve their tools to meet those needs. This can be seen in the evolution of the Jeliot animation system since it was first used in 1998. There were many features and options that were add to the system as a result of my research into teachers' needs.

7. My study used a novel methodology constructed by integrating two well known methodologies. One, the theory of planned behavior, is quantitative, and the other, phenomenography, is qualitative. I showed how these two very different methodologies complemented each other. The integrated methodology enabled me to reach deeper and better conclusions than I would have been able to do with either one by itself.

To summarize: This research gives a new perspective on CS teachers and their experience with software tools, especially educational technology tools. CS teachers are perceived by the community as experts in using technology. The reason is that these teachers were trained to use technology and in fact they use very advanced software tools in their classes. But, when it comes to animation systems, my study showed that the teachers have control problems. The control problems do not relate to the use of the tool but to pedagogical issues. I found that CS teachers do not feel comfortable to admit that they have pedagogical control problems because of the way they are perceived by the community. I suggest that animation systems should be introduced to CS teachers not only in a technical manner of how to use it but also in a pedagogical manner on how to teach with animation systems.

2. BACKGROUND

This chapter is divided it into 5 subsections dealing with issues that my study refers to. A summary of each sub-section is given at the end of the subsection.

2.1 Teachers as the Connecting Link Between Curricula

The object of my study is the CS teachers. Teachers are the ones who are supposed to bring innovations into their classrooms, and there is a broad literature concerning teachers, teaching etc. My study deals with teachers and their use of an animation system as a pedagogical tool. The use of an animation system in class could be perceived as a change in the curriculum; therefore I bring also definitions of dimensions of curriculum.

In the literature the term *curriculum* has several varied dimensions. Some of the dimensions deal only with the official syllabus, while others include also the rationale, the content, textbooks, teacher guides, and other teaching materials (Clements, 2002). Doyle (1992) says that there are several meanings because curriculum processes operate at several levels of schooling (p. 69). Au (2007) says that "to stop at the level of content in curriculum obscures other crucial aspects of curriculum because subject matter content within schools implies not only *selection* but also *transmission* of knowledge" (p. 258).

2.1.1 Dimensions of curriculum definitions

Duggan-Haas, Enfield, and Ashmann (2000) say that The National Science Education Standards define curriculum as "the way content is delivered . . . the structure, organization, balance, and presentation of the content in the classroom" (NRC, 1996, p. 2, as cited there). They also say that "The Third International Study of Mathematics and Science identifies three major dimensions: the *intended curriculum* (goals and plans), the *implemented curriculum* (practices, activities, and institutional arrangements) and the *attained curriculum* (what students actually achieve through their educational experiences)" (Schmidt, et al., 1996a, p. 16, as cited there). From this citation I learned that the content of the material affects the teaching process, but according to the citation there is no identity between what is written and what is being taught.

This can be seen also in Reys, Reys, Tarr, and Chávez (2006, p. 11). In this article the researchers *counted* the number of times that teachers use material from the intended curriculum. In my study the analysis is different from counting, because I observed the *way* the animation system was used.

Remillard (2005) cites theorists who distinguish between the intended and the enacted curricula. The author gives the curriculum theorists' definitions of categories to describe different types of curriculum: (1) *Formal curriculum* refers to the goals and activities outlined by school policies and textbooks. (2) *Intended curriculum* refers to what teachers aim to do in class. It contains the rationale of the content knowledge, and the pedagogical instructions. This declaration refers to instructional aids such as text books and visualization tools. It is connected to the formal curriculum that is supplied by the educational authorities. (3) *Implemented / Enacted curriculum* refers to what actually takes place in class. This declaration refers to the practice the way teachers perceive the official instructions, etc. It deals also with the institution, which includes the school environment and its policies (Cobb, McClain, de Silva Lamberg, & Dean (2003)). (4) *Attained curriculum* refers to the students and their achievements from the curriculum (i.e., their grades).

Other authors suggest additional categories of curricula: (5) *Lived Curriculum*: Marton and Tsui (2004) added another definition (in CS), which refers also to the students and deals with what they eventually understood from class. (6) *Potentially implemented curriculum* is presented by Johansson (2005) who brings the model suggested by Valverde et al. (2002, as cited there, p.120). The model suggests that the potentially implemented curriculum is the mediator between the intended curriculum and the implemented one. The textbooks and the teaching materials according to this model belong to the potentially implemented curriculum.

I concluded that in order to decrease the difference between the intended curriculum and the enacted one, we should pay a lot of attention to the teachers as the connecting link between them. Moreover, we should be aware of the fact that although there could never be an identity among the above dimensions, we can try to bring them as close as possible.

2.1.2 Teachers and their interaction with curriculum

In the field of mathematics, there are many studies that indicate a difference between the intended and the enacted curricula (Cohen & Ball, 2001). Freeman and Porter (1989) found that there were important differences between what is written in the curriculum and the teachers' selection of topics, in the content emphasis and in the sequence of instruction. Freeman and Porter say that in spite of the fact that their study involved only four teachers and that the data was collected 10 years ago, the results represent general practice even at their time. They say that their recent analysis of teachers' content decision gives a very similar picture (p. 418). I learned from this that teachers still make their own decisions when they face curriculum materials.

Doyle (1992) describes the situation that “teachers have been viewed as instruments to be managed to ensure that they carry out the system-level requirements for teaching effectively” (p. 66). Doyle adds that “teachers are curriculum makers who guide students through the texts, shape the interpretations that are allowed on the floor, and, importantly, define tasks that students are to accomplish with respect to these texts” (p. 76). Here Doyle conceptualizes teachers on a higher level since they are using their own understandings of the material in order to bring it to their students in the most responsible way. Moreover, he concludes by saying that “the choices that teachers make with respect to the content of the material have enormous consequences on the lives of the students” (p. 77). This article emphasizes that it is very important to understand that teachers give their own interpretation to the curriculum materials and we should take into account their decisions.

Ball and Cohen (1996) say that in the USA teachers shape the curriculum in fundamental ways. The reason is the lack of guidance from the developers. This leads teachers to understand the material according to their beliefs about what is important for the students, and according to the way the teachers perceive their role in class (p. 6). This situation creates a gap between the intended and the implemented curriculum. In their article, the authors describe a situation in which teachers disparage or reject the curriculum materials; many of those teachers are “reform-oriented” (p. 6) so they create an idealization of professional autonomy since the good teachers who make reforms do not use text books, but they make their own curriculum. These teachers were perceived as more creative than those teachers who teach by-the-book. Another reason for the teachers’ negative approach towards the curriculum materials is anchored within the developers’ assumption that curriculum materials can operate nearly independently on students. The authors state their own perspective on using curriculum materials: “Curriculum materials could contribute to professional practice if they were created with closer attention to processes of curriculum enactment” (p. 7).

This leads to the need to study the *beliefs* that teachers posses towards the material. We should deal with the teachers who reject the curriculum materials, and try to deal with their attitudes towards those materials. The teachers with the negative attitudes are very interesting. Raymond (1997) discusses the issue of beliefs on mathematics and teaching practice with a novice mathematics teacher. When these beliefs affect teaching practice, it affects the enacted curriculum.

In spite of the understanding that curriculum materials cannot operate independently on students, I have found that developers of animation systems still believe that it will be enough just to put the systems in front of the teachers and the students and results will come. I will refer to this item again in the literature review on educational technology.

Price and Ball (1997) argue that classroom practices in many places in the United States continue to be "as conventional as ever," despite the fact that "contemporary reforms in the US urge deep changes in mathematics teaching and learning" (p. 637).

Spillane (1999) deals with the difference between the intended curriculum and the enacted one by trying to understand what motivates teachers to change their practice. He describes a new term "zones of enactment" (p. 144) as the space in which teachers' the capacity, will and prior practice interact with the motivation from policy makers as well as the students' reaction to the change in the teaching process. Spillane developed the "six Ps" model for this interaction. The model deals with society and policy makers as well as with the school system. In later article we will meet these items as institution, schooling, etc. From this article I concluded, again, that there is a difference between what policy makers want and what is really being taught in class.

I found the following citation: "Teachers tend to teach as they have been taught" Reys, Reys, Tarr, & Chávez (2006, p. 5). (They cite Ball (1987) and Boaler (2002) as the source) This will be related later to the way CS teachers use an animation system (cf. the discussion of the By-the-book category in Section 5.1.2).

Eisenmann and Even (2008) and Eisenmann (2007) studied different classes taught by the same teacher, in particular, while focusing on the implementation of the recommendations for instruction structure in each of the classes, and the types of algebraic activity that the students were exposed to during the learning of the topic. In other words, they studied "the way the enacted curriculum may change when a teacher uses the same intended curriculum in different classrooms" (p. 4).

In biology I have found that the term *difference* between the intended curriculum and the enacted curriculum is not being used (Falk, Brill, & Yarden, 2008). In this case, the researchers were looking in how teachers bring the intended curriculum to the classroom (enacted curriculum). Although the curriculum materials were very specific and contained instructions on how to use the materials in class, the teachers have room for their own interpretation of how to bring the materials into classrooms.

In 1997, a historical overview of the CS curriculum was conducted (Goldweber, Impagliazzo, Bogoiavlenski, Clear, Davies et al. 1997). In 1968, the first curriculum was written (Curriculum Committee on Computer Science, 1968), and the group says that "[U]nfortunately the literature is sparse on formal assessments of curricular and pedagogical directions" (p. 106).

2.1.3 The use of curriculum materials

The term "use" was defined in several ways (Remillard, 2005): (1) *following the text* – the assumption is that teachers should follow the instructions of the developers as written in textbooks; (2) *drawing on the text* – teachers are the agents who read the material before class and use it to construct a lesson. The teacher can choose activities from a pool of material given by the curriculum guide; (3) *interpretation of the text* – the assumption is that there could not be fidelity between the curriculum text and the classroom action. Moreover, teachers bring their own beliefs and experience to create their own meaning of the curriculum; (4) *participation with the text* – the assumption is that the curriculum might change according to the use of the teachers. The teachers are conceptualized as researchers that influence the curriculum. Remillard's way of defining use is closer to my study since I have found four qualitatively different ways that CS teachers use animation systems as pedagogical tools. Reys, Reys, Tarr, and Chávez (2006) *counted* the number of times that the implemented curriculum materials were enacted in class. Eisenmann (2007, p. 47) and Eisenmann & Even (2008) empirically checked how teachers used curriculum materials by counting the amount of time the teachers spent in class on activities as suggested by the developers of the mathematics' curriculum.

Falk, Brill, and Yarden (2008) do not count the times curriculum materials were used by the teachers; instead, they looked to see if the teacher followed the theme of the curriculum, for example, by encouraging students to conduct inquiry and not just read about a topic.

This is another way to measure the difference between the intended curriculum and the enacted one. I think that in this way the researchers see the intended curriculum as a live thing that is the basis for what teachers do in class, while the counting perceives the intended curriculum as a book of rules that should be followed. In a sense I think that this flexible meta-view of the intended curriculum gives more space to the teachers and will encourage their willingness to adopt curriculum materials.

Milne, Scantlebury, and Otieno (2006) try to understand the relationship between teacher change and a science-based professional education program. The researchers conclude by saying that "introducing new tools into a classroom required the teachers to exert more effort than if they used their habitual practices" (p. 347). The researchers emphasize that it cannot be related to the laziness of a teacher. It is related to sociocultural environment that surrounds the teacher, the school, the fact that the teacher is new in a school etc. They say that:

> There is a tendency in professional science education to focus on the new tools that teachers are learning and teachers may argue they need new tools that have immediate application to their teaching. However without an examination of attendant schema, teachers may use resources in purposeless ways or associate them with schema the teacher already values resulting in a teaching/learning structure very different from that envisaged by the professional educators. (p. 348)

This study deals with chemistry teachers. Although I am investigating the ways that CS teachers accept/reject a new tool, I agree with these researchers who say that the teachers should be in the focus and not only the tool, so that there would not be a difference between the way the professional educators envisaged the use of the tool and the way the teachers employ the tool (or not).

Cuban (1986) describes the classroom use of technology since 1920. He describes a dream of "increasing productivity, that is, students acquiring more information with the same and even less teacher effort" (p. 3). This dream can be accomplished by using technology like films, video and computers. He describes the process of the innovators being enthusiastic towards the new technology and the result was that "Seldom were these innovations initiated by teachers" (p. 4). Cuban gives several reasons for not using the technology; the reasons are anchored in the beliefs that teachers possess towards the effectiveness of the use of the technology, the school system, the role of teachers as technicians, etc. Cuban concludes by saying:

> In reviewing the literature on schools and classrooms over the past century, changes, both intended and unintended, can be detected. These changes occur as a result of stable processes of change, ways that schools and classroom teachers respond to their environments. Only a tiny part of these changes are the designs of policy makers (p. 106).

> Those who have tried to convince teachers to adopt technological innovations over the last century have discovered the durability of classroom pedagogy. (p. 109)

This article describes the fact that changes take time; if changes finally occurred, they were not all at the same time, as designed by the innovators. The innovators usually are very fond of their product while teachers have their own criticism.

Borko (2004) says that the changes in classroom practices demanded by the reform visions ultimately rely on teachers; she cites Fullan & Miles (1992; Spillane, 1999, as cited there) in order to emphasis her claim. She says that there should be a lot of effort given to teaching teachers in order to succeed in a reform.

2.1.4 Reasons for failure of reforms

Ball and Cohen (1996) say that one of the reasons for failure "is that the curriculum developers and others often have failed to take account of the teacher" (p. 6). They say that in the late 1950s and early 1960s innovators failed to appreciate that teachers' need to learn in order to use new materials. From this article I have learned that the teachers' needs should be voiced.

Manouchehri (2003) describes the situation of teachers' reluctance to perform reforms in mathematics education. She found that teachers who are confident in their ability to control student learning and curriculum are willing to make changes in the curriculum. The author writes that:

> The finding of the current work, while substantiating the theories of these researchers on the centrality of the teacher's reflective disposition on her ability to sustain innovative practice, extend their theses by proposing that analyzing teachers' work solely through the lens of their enacted curriculum, or mathematical goals may be limited. (p. 226)

The author claims that even if teachers decided to make a change, they regress very soon. The teachers in her study acted the same, but they believe that they were judged without taking into account their overall goals and long term plans. Manoucheheri says that more study is needed about the teachers' beliefs and the way they perceived their role in class. She concludes that the more the teachers feel confident in their control over the students and the curriculum, the more they will take risks such as trying innovation and changes in the curriculum.

In my study I am looking for the attitudes and beliefs that teachers possess towards a specific tool and not the enacted curriculum, as described in the article. This is done in order to predict whether a teacher will use a software tool or reject it.

Cohen and Ball (2001) claim that in order to make a change it is not enough to have a new curriculum. They are pointing at institutions that do not provide the basic needs that teachers need in order to make the changes needed by the reform: (1) the lack of professional development courses; (2) the time schedule that does not give an opportunity for discussions between teachers, even not for the tasks that the teachers should do together as the developers of the reform expect them to do; (3) teachers are afraid to make revolutions in class in order to maintain the students' good spirit. The teachers do not want to take the risk of failure. This article made me aware of the idea that I should also check the influence of the institution on the decision of the teachers to use or reject Jeliot. In the TPB methodology, this is measured by the subjective norms predictor.

Davis (2003) describes the process of making a change. Davis reports on teachers who are early adapters, late adapters and resistors. She describes making a reform as a "complex process and difficult" (p. 27) and "change doesn't happen overnight" (p. 23); people have different starting points so one cannot "expect everyone to be in the same place" in the change process, "but moving along" (p. 23). Levy-Nahum (2007) (p. 96) supports these findings too. Therefore, it should be taken under consideration that changes take time; moreover, the different starting points are related to the beliefs and the experience of the teacher, so it is very important to study those beliefs before designing a change and not after a new curriculum appears.

Agudelo-Valderrama, Clarke, and Bishop (2007) tried to understand the fact that teachers do not change their practice according to the demands of the intended curriculum. They found that making the change depended upon the attitudes that the teachers possess towards the new curriculum and their own role in the classroom. Moreover, they found that the more self-efficacy the teachers believed they had, the more they would be willing to make the change. "This study has shown that the teachers did not see their conceptions of mathematics as the crucial determinant of their teaching practices. Instead they saw factors belonging to the social/institutional context of their teaching as the main reasons for what took place in their classrooms and for the difficulties of introducing change in their teaching" (p. 88).

In my study I am trying to understand the negative ways of experiencing an animation system by teachers. Similar to the study of Agudelo-Valderrama, Clarke, and Bishop (2007), I have found that it is connected to the *centrality* (the central role) of the teacher in class, and to control (self-efficacy). On the other hand, the institutional reason did not arise. Moreover I could not find any characteristics of normative beliefs that teachers possess. I will expand on this idea later.

2.1.5 Research on teachers' attitudes and their influence on teaching

Integrating a technological computer-based artifact into teaching requires changes to many aspects of the classroom. This process will be affected by the teachers' prior teaching styles, and their beliefs about the subject matter and how it should be taught. Moreover teachers are the key agents when it comes to changing classroom practice (Spillane, 1999).

A study performed in this area described different ways of organizing the classroom, and a variety of approaches to teaching the use of CAS (a technological tool for teaching mathematics that has symbolic and graphical capabilities) (Stacey, Kendal & Pierce, 2002). This variation is grounded in the differences among different teachers' perceptions on the way they believed that CAS would help students. The teachers' concepts on the environment were different. One believed that using CAS and its graphical capabilities would give his/her students a better conceptual understanding of calculus; therefore he used the tool in class as an integral part of the general discussion. The other teacher did not enjoy teaching with CAS, as expressed in an interview:

> "Actually, I tried to bring in the [graphics calculator] but I had real trouble with it. I thought 'I just can't be bothered' and I haven't [used it in class] since. I didn't feel comfortable with the [graphics calculator] because I had so many problems"

This teacher used CAS with a projector and the students did not use CAS by themselves. CAS was used as a calculator only, and the teacher did not use the graphic mode at all. This emphasizes that the teachers' lack of experience may influence their decisions on integrating technological equipment in class.

Zbiek (2002) studied six teachers' attitudes towards the use of CAS in class; two of them were the above teachers. The researcher found "evidence that the teachers – at least initially – found very little need for and made minimal use of the symbolic manipulation component of CAS in the materials." Zbiek stated that the use of CAS reflected the teachers' conceptions of the role of the teacher. She said that using CAS in class changed the teacher's role to one of technical assistance and facilitation. Furthermore, previous experience with technology also influenced teaching with CAS. There was a difference in integrating CAS in lessons resulting from teachers' differences in experience in technology and CAS knowledge. The researcher said that that was natural when a "teacher operates from a teacher-centered presentation mode and creates a classroom setting in which students use their tools to recreate teacher demonstrations." Another perspective given in this study was the way that teachers see the ability of their students. Teachers who considered their students as less mathematically capable than others used a different kind of lesson than other teachers.

Spillane (1999) stated that teachers play a key role in the acceptance of external reforms that bring about changes in classroom practice. He claimed that local enactment depends in great part on the *capacity* and the *will* of teachers. The term *will* referred to teachers' motivation to change their practice to carry out reformers' recommendations, while *capacity* concerns educators' ability to practice in ways recommended by reformers. He considered the interplay of incentives and opportunities for teachers to learn about a practice with the teachers' capacity and will to reconstruct their mathematics practice.

My study deals with teachers and their attitudes towards the use of animation system as a pedagogical tool. The above review shows the difficulties that teachers face whenever they want to or are asked to integrate a software tool into their practice. As I found above, the attitudes influence the capacity, or, as I will refer to it later, as perceived behavior control.

2.1.6 Research on teachers' knowledge

I believe that teachers have an important role in assimilating the use of animation systems to the teaching process. This belief can be interpreted from the findings in Shulman (1986) who said that teachers must project an understanding of both content and process. Shulman outlined an alternative to the conflict between subject knowledge and pedagogy in teacher education. He argued that through viewing content and pedagogy as equal parts of a larger body of knowledge, better methods for educating and testing future teachers can be developed.

Shulman (1986) not satisfied with the fact that assessment of teachers was mainly pedagogical and was not concerned with subject matter – 'the missing paradigm'. He suggested that subject matter and pedagogy are equally important in assessing teachers, and must have equal parts in tests desired to identify better teachers. He built a theoretical frame to describe teachers' knowledge. The framework included three topics that are related to the subject matter: (1) Subject matter content knowledge – this knowledge includes facts, structures and what is scientifically correct; (2) *Pedagogical content knowledge* (PCK) – this knowledge includes different ways to present a subject in order to explain it better, case studies, and misconceptions; (3) Curricular knowledge – this knowledge includes the curriculum, the order of teaching, familiarity with teaching aids that can enhance the students' learning.

I believe that the use of animation in class is connected to all of the above three topics. Teachers who use animation systems in their class must have PCK in order to approach students' misunderstandings and to use well-known case studies. Teachers have to decide on a teaching sequence, which is coherent and scientifically correct. It is not enough to know the subject matter. Teachers have to know how to present and represent it to their students; and that is, teachers must posses PCK. This approach is also described in Ball, Lubienski, and Mewborn (2001).

Wilson, Shulman and Richert (1987) dealt with PCK as well. They said that PCK is not only "a repertoire of multiple representations of the subject matter", but that it also describes a way of thinking. They state that knowledgeable and experienced teachers sometimes choose to teach in a different order from the one suggested by a book, and they know what kind of explanation or representation is needed. This way of thinking is called *pedagogical reasoning*, which is a cycle of understanding the subject matter, transformation of knowledge, presenting the subject, evaluation and reflection.

In her study Even (2005) concluded that teachers had problems in making sense of a new assessment approach. She claimed that according to the four examples shown in the study, teachers always *hear through various personal resources*, such as the teacher's knowledge, understandings, beliefs, which leads to sometimes misunderstanding of the students' behavior. I showed in my research (Ben-Bassat Levy, 2001) that animation systems mediate the medium in such a way that students and teachers can understand each other, and therefore interaction between them is better than a simple conversational situation.

2.1.7 Research on teachers and their reaction to change

Teachers are occasionally asked to make changes in their practice. The changes can be grounded in changing curricula or political waves, etc. There is a lot of research done to investigate the teachers' reaction to these changes. My research deals with teachers and their reaction to the use of an animation system as a pedagogical tool, which is a change in the teachers' practice. The following review is ordered chronologically, since I want to get an idea about the reaction to changes over a period of time.

Fensham (1988) described the situation in the 1960s when reforms in science education were established to create a more scientifically educated citizen. In order to achieve that goal, a new curriculum for science education was developed. Those reforms failed and the perception then was that "the problem" originated with teachers. Fensham claimed that during those years, few thought that the school system was a problem; however, he thought that the school system had a role in the failures. The author emphasized that collaboration among teachers, and with curriculum developers for sharing of ideas, information and experience is important for the success of reforms. "It also leads to a more realistic recognition that teachers need time and support from outside themselves if such sharing is to bring about changes in their behaviour and in the learning of their students" (p. 24).

Borko, Eisenhart, Brown, Jones, and Agard, (1992) attempted to understand *why* a Mathematics lesson failed. During this lesson the teacher tried to represent a concrete model of dividing fractions. The interview before the lesson showed that the teacher did not think about a representation to use in demonstrating division of fractions when planning a lesson. In fact, she did not plan to provide a conceptual explanation at all. She thought that the students already knew it from previous lessons (p.198). The questions raised by the researchers were: What did she know and believe about teaching division of fractions? Why she did not try to look for another representation? What about her Pedagogical Content Knowledge (PCK)? The authors used Shulman's theoretical model of domains of teachers' professional knowledge (Shulman & Grossman, 1988 as cited there) to develop the knowledge and beliefs component of their conceptual framework. (The figure below is taken from the article)

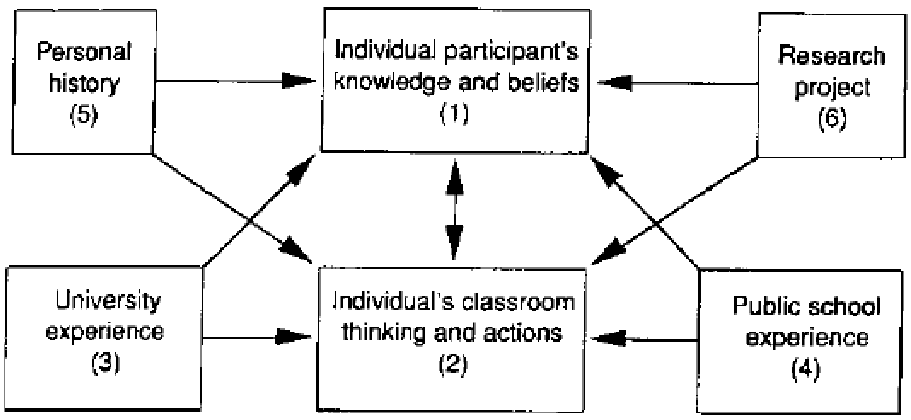

Figure 1. Becoming a middle school mathematics teacher.

The researchers interviewed the teacher at the beginning of the year and at the end of it; this was the primary source about her perceptions and beliefs. They also observed her lessons. Another source of information was a questionnaire describing a situation in class and asking for the subject's reaction. The authors found that the teacher believed that "A person learns to teach mathematics through practice," and they claimed that this belief is shared by many teachers (p. 219). The authors concluded by saying that these beliefs affect the teachers' ways of teaching, and that teacher training programs should give attention to pedagogical training as well as content training. Teachers believe that learning how to teach is a result of practice and that each lesson contributes to their experience and can affect their teaching methods.

The use of computers in class, especially ones that are used as artificial intelligence tutors, causes teachers to become frightened (Schofield, 1995). This change in the curriculum caused teachers to feel that they are not needed in class. Schofield concludes by saying that computers "cannot replace teachers, but even if they could, the question if they should … remains" (p. 206). She claims that such a change in the curriculum affects the role of the teachers in class: they became more collaborative than before, and they had to function less as authoritative experts and more as facilitators.

Jenkins (1995) described legislation that required schools to teach and assess "scientific investigations." In the article, problems were discussed including: (1) the problem of the teachers who had to teach in a way that they were not familiar with; (2) the curriculum that was not very clear; (3) the inadequate technical support. The author concluded by saying that it is not enough to legislate a curriculum change; professional development courses must also be conducted.

Borko and Putnam (1996) were interested in how experienced teachers attempt to make changes in their teaching practices. They checked the role of prior knowledge and beliefs in learning to teach (p. 674). The authors said that "contemporary cognitive theories view learning as an active, constructive process that influences an individual's existing knowledge and beliefs and is situated in a particular context. But all the above aspects are also critical in shaping what and how the teachers learn from teacher education experience. Moreover, those beliefs and conceptions are difficult to change" (p. 674). They concluded by saying that "teachers' role as a mediator of meaningful student learning is very important" (p. 675), and the teacher has to have a repertoire of classroom activities so that the lesson will run smoothly. The repertoire depends upon the pedagogical knowledge of the teachers. The learning process influences the beliefs that teachers possess and these beliefs are very difficult to change. Changing the role of the teacher to a mediator of students' learning requires changes in the way that teachers see themselves.

Prosser and Trigwell (1997) wanted to find out how approaches to teaching relate to perceptions of the teaching environment, especially in higher education. In a previous study

(Prosser, Trigwell, & Taylor, 1994), the authors found five qualitatively different teaching approaches in a phenomenographic study. Those approaches are the *inventory* (as they call it) that was used in this study. (p. 27). That inventory is hierarchically arranged from teacher-focused strategy with intention of transmitting information to students (low) to a student-focused strategy aimed at students changing their conceptions (high). The study showed that teachers who are usually teacher-focused tend to have negative perceptions on their class environment, while those who are student-focused tend to have positive perceptions.

Underwood (1997) investigated the effectiveness of integrated learning systems (ILS) in schools. The ILSs were supposed to organize the work programs in school. She found that the initial responses of the teachers to these systems varied from relief by a very few teachers to disbelief by many teachers. The ILSs caused an uncomfortable situation to the teachers "who felt their own professional expertise was being brought into question by a 'box'! This discomfort was compounded by the fact that teachers began to lose track of their own pupils' learning" (pp. 7). Although the students had positive responses to the teaching styles, the teachers began to feel excluded from the educational process.

Fullan and Hargraves (1996) stated several reasons for resisting reforms and changes by teachers, among them: (1) Experienced teachers have their own routine in teaching and they have very little motivation to look for new climax; (2) Novice teachers are engaged in survival and are therefore afraid to use novel methods; (3) Teacher development courses do not give sufficient attention to pedagogical aspects.

Manouchehri (1999) conducted a survey in order to investigate the extent to which computers were being used by school mathematics teachers. The author reported that mathematics teachers do not use computers in their classes although it was encouraged by reform movements. She also remarked that there is lack of documentation about the reasons for not using technology (p.32). The author studied 181 responses of teachers to a questionnaire and found that only 15 used computers: ten reported using computers exclusively, but only four provided examples that they used. Manouchehri concluded that there are four main reasons for not using computers: (1) Lack of experience in access to educational software; (2) Lack of knowledge about how to integrate computers in class; (3) Lack of knowledge about exploratory activities; (4) Lack of professional training and support in the use of computers in mathematics instructions. The researcher proposed a model of teacher training explicitly addressed to the issues of content knowledge and pedagogical skills, where active learners use the technology hands-on while observing how the technology is used by experts.

Spillane (1999) dealt also with the change of practice, I wrote about this in Subsection 2.1.2 on the interaction with the curriculum.

Cuban, Kirkpatrick, and Peck (2001) studied why there is an anomaly between the belief that technology will improve teaching and learning, and the reality of its low use in high schools. Only a third of the teachers they investigated reported that they changed their pedagogy: they lectured less and acted more like a coach, and they gave their students more independence. The teachers changed their teaching methods to be more student-centered. The other teachers said that although they used computers in class and for personal use like word processing, they did not change their pedagogy. The reasons given for not using computers in the class included: (1) Teachers do not have the time to find and evaluate the software; (2) Teachers are not trained to use computers in class, nor are they trained to use the software, or the training they did receive is irrelevant.

The authors try to explain the situation; the first explanation is based on the idea of a "slow revolution": small changes need time in order to create transformation (p.826). This idea is grounded on the fact that it takes time from the invention of a new technology, through the initial adoption and finally the recognition of its advantages in the population. According to the slow revolution explanation, the adoption of computers for instruction by teachers began when teachers used computers for preparations of classes and for communication. But later research showed no increase in the number of teachers using computers in class (Cuban, 1986 as cited there).

The second explanation deals with the context of high schools, their structure and their use of time. The main role of high schools is to prepare students for college; therefore the school context and the teaching methods were adapted to this role. Any change is difficult since teachers who worked six days a week had difficulties in training because they had to study on their free time. Moreover teachers who were used to be teacher-centered had to change their role to student-centered and they found this very difficult.

Cohen and Ball (2001) studied the teachers' reaction to changes and I cited them in Subsection 2.1.4 on the reasons for failure.

van Driel, Beijaard, and Verloop (2001) wrote that teachers are the most influential factor in educational change. However, the crucial role of teachers in efforts to reform the curriculum may be assessed from quite different perspectives. In a traditional top-down approach, the lack of success of many innovative projects is attributed to the failure of teachers to implement the innovation in a way corresponding to the intentions of the developers. This is also known as the Dienes effect (Sierpinska, 1999). In this approach, the curriculum developers are assumed to know how the curriculum has to be changed and how teachers have to adapt their teaching practice, that is, change their classroom behavior. In their article the authors cite research on reforms and the criticisms made about them, especially the fact that the teachers' perceptions, thoughts, knowledge, feelings, beliefs, etc. were ignored by the developers of the reforms. They claimed that teachers are used to work in a familiar environment and they are not easily persuaded to change it to an environment where they feel uncomfortable.

The authors conducted a large literature review on science teachers' knowledge and concluded that: experienced science teachers, as opposed to novice teachers, have developed an integrated set of knowledge and beliefs, which is usually consistent with how they act in practice. They found that when trying to make changes in the curriculum several problems may occur. First, teachers do not know the new content or the pedagogical changes needed in order to implement the new material in class. Second, teachers' beliefs with respect to the new content or pedagogy may differ from the intentions of the innovation. The authors said that short intensive courses can be helpful in upgrading the teachers' content knowledge and the teachers' ideas about the innovations, however, when teachers are asked to put an innovation into practice, problems are reported in all studies. For example, inconsistencies often occur between teachers' expressed beliefs and their behavior in the classroom. In order to deal with these inconsistencies long-term staff development programs are proposed to actually change experienced teachers' practical knowledge. "Teachers need to restructure their knowledge and beliefs, and, on the basis of teaching experiences, integrate the new information in their practical knowledge" (p. 148). Therefore, they suggest that reforms must operate professional development programs that consist of: (a) an explicit focus on teachers' knowledge and beliefs throughout all stages of the reform; (b) collegial cooperation or exchange between teachers; (c) sufficient time for changes to occur: at least one semester and perhaps several academic years.

"Integrating a powerful instrument such as Computer Algebra System (CAS) into teaching requires changes to many aspects of the classroom, which teachers will make from the base of their prior teaching styles and their beliefs about mathematics and how it should be taught" (Stacey, 2001). She describes different ways of using CAS in teaching: (1) The use of CAS to explore a problem and make it easy to perform difficult calculations through the use of graphical information to explore the derivative of the function. The teacher is experienced and functions as a facilitator, bringing issues for discussion in class; (2) When a teacher does not like CAS because he/she is used to lecturing, his/her way of teaching with CAS is to use a projector and allow the students to copy notes of what they see.

The author refers to the differences that result from teachers' attitude towards solving problems and towards the CAS itself. Both teachers had to make a transition in the way they teach. They used the CAS in class although they did not like it equally. It took them time to adjust to the new environment. The author does not describe a situation of rejecting the CAS environment by a teacher.

Zbiek (2001) claims that the teachers' view of mathematical learning influences their use of CAS. She describes a variation of teaching methods from demonstrations through technical use up to inquiry. Their approaches varied from teacher-centered to student-centered pedagogy.

One of the major findings of the study conducted by Henderson (2002) is that instructors make decisions about what resources to provide based upon three perspectives (p. 131): (1) The perspective of the effect on student learning; (2) The perspective of requirements on the instructor's time; (3) The perspective of the match with student preferences. Although the perspective of the effect on student learning has not been explicitly identified in previous studies, many studies appear to make the assumption that this is the main consideration of teachers. The perspectives of the instructor's time and the match with student preferences have been identified in previous studies (p. 39 in the thesis of Henderson).

White (2003) claimed that "a new curriculum means change for experienced teachers and new forms of training for those who are yet to enter the profession" (p. 179). For the experienced teachers, these changes require new skills and different script of teaching than they are used to for many years. He emphasized that making revolutions in teaching methods could not be carried on without the experienced teachers. But there is a problem in changing the script: since people are used to it, they feel confident while teaching according to it. He described a situation where people use scripts during their daily life, and when they have to change it they feel strange, as if they were in a different country. In order to overcome those feelings, he suggested in-service training that will apply to the teachers' beliefs so that they would easily accept the changes. He believes in long-time training, but said that it could not been done since the budgets were reduced. Another problem that he raised was the low payment for teachers and the fact that teaching was not an attractive profession. He suggested that a professional development program that involves teachers as agents of the new curriculum is good. The agents could be experienced teachers that were not locked into their general script of teaching.

Midyan (2003) conducted a survey to investigate the factors that influence the ability of teachers to adopt a change from indoor classrooms to an outdoor learning environment. She found a gap between the enthusiasm and declare interest of teachers upon being exposed to the change, to the change that was implemented (if at all) in practice. (I encountered a similar situation with respect to the Jeliot animation system, as described above.) Midyan categorized the factors responsible for this state as technical, content and emotional. She found that while the technical difficulties can be easily overcome, the other two require support, scaffolding and fading by experts (p. 79).

Hofstein, Shore and Kipnis (2004) reported on a case study that involved an inquiry laboratory in chemistry. A professional development course was conducted for the teachers who chose this type of assessment for their classes. The program demanded the teachers use the materials in order to increase their confidence in the inquiry laboratory. The authors report that based on their observations, feedback questionnaires and interviews, the professional development program was very important for the success of the project. The teachers reported that first-hand experiences increased their confidence and reduced their anxiety that resulted from the changes in their role in class.

Hofstein and Lunetta (2004) report that excellent teachers who are able to facilitate inquiry-type laboratories nevertheless continue to hold conventional beliefs that knowledge is directly transmitted to the students and that it is to be remembered as conveyed (p. 45). The authors emphasize that good grades are not the sign of good teaching.

Hofstein, Navon, Kipnis and Mamlok-Naaman (2005) describe the role of the teacher as a facilitator. They write that many teachers feel that they are judged according to the grades of their students, so they have to guide their students' work and not let them inquire by themselves. The authors suggest paying more attention to the teachers and to change professional development programs to enhance both content and pedagogical knowledge, so that teachers experience activities that increase their self confidence.

Booth and Anderberg (2005) set out to improve teaching at the Chalmers University of Technology. The conceptual framework of the Chalmers program was intended to support teachers in coming to understand their practice and to improve it in principled ways through theoretical grounding. While teachers generally came with a wide range of worries and interests grounded in practice and experience, together with an expectation of improving their performance in a behavioral sense, the researchers interacted with them from a theoretical research-based understanding of facts of university pedagogy, and with an aim to shift their focus towards the more stable base of theoretical understanding. The aim of the investigation was to describe and analyze the teachers' experiences of how the courses were related to their teaching practice. The results show that some of the teachers felt that they had to communicate in a new language, some of them felt overwhelmed by the pedagogical theory, and most of them felt that they had a better connection with their students. Some of the teachers were disappointed from the course they felt that it was too theoretical. Although this study deals with university, not high-school, teachers, even in this case we can see that they had problems in adapting the new way of teaching.

Even (2005) discusses the use of innovative assessment methods and tools that teachers were taught in a professional development course. These methods were intended to improve teachers' understanding of what their students say and write. Most teachers did not use these methods in the way they were taught in the course, and some of them did not use it at all. The author states that the literature on assessment deals primarily with the use of novel methods and tools, but not enough on how teachers can use the assessment results in order to make decisions. She also claims that "it appears that attention is often given to teaching teachers how to integrate into their teaching a combination of new assessment methods and tools instead of the traditional tool of paper-and-pencil tests administered at specified times. But not as much attention is given to ways of using the richer information acquired about students to make instructional decisions and advance students' learning" (pp. 18–19). Even refers to the fact that it is not enough to improve the use of new assessment tools; moreover, ways of using tools should be given as much attention as teaching them the new tool. Even discusses also the fact that the literature is sparse on how teachers integrate into teaching the new tools they have just been presented to. There is little information about how teachers integrate into teaching new tools. New assessment tools are not used in class in the way they were taught in the course. Teachers do not get enough information in how to integrate the new tool.

Toprakci (2006) has studied the obstacles that face the integration of Information and Communication Technologies (ICT) in schools in Turkey. Although ICT entered the school, it did not enter the classrooms, and most computers are still being used for the purposes of computer literacy. The researcher found that the program failed for several reasons, some related to budget cuts and inadequate teacher training, while others were related to the teachers not begin open to change. In any case, the researcher did not study the reasons for this behavior of the teachers.

2.1.7.1 Teachers are viewed as agents of reform

The literature in this Section is summarized in the following Subsections.

Teachers are supposed to be the agents who bring innovations and integrate them into their own classes (Elbaz-Luwisch, 2001). She claims that many attempts to improve teaching according to theoretical models did not succeed, and the resistance to innovations is connected to the teachers' common sense, since they must work harder without additional pay. Another explanation for failure is that the teachers do not teach as they are expected to (van Driel, Beijaard, & Verloop, 2001); therefore, they are blamed for the failure of an innovation. Fensham (1988) and Jenkins (1995) referred to the common perception in the 1960s that teachers were the cause of unsuccessful reforms as "the problem." Cohen and Ball (2001) illustrated a situation in which teachers had neither a professional development course for a new curriculum, nor the time to consult with experts and colleagues about their problems in using it. The same point can be found in Jenkins (1995). White (2003) suggested that the agents of change should be experienced teachers who are not locked into their "scripts." Spillane (1999) dealt with the space in which teachers could make changes in their practice in class. His study suggested that teachers have their *zones of enactment* which affect the teachers' willingness to make a change. Spillane (1999) and Fensham (1988) both discussed the *institution* problem, in which the school system affects the success or failure of a reform. Each reform and innovation that is concerned with changing the curriculum or changing the tools needs teachers to carry it out and this claim appears in each of the studies I have reviewed. Since teachers are the link to establish innovative reforms, reformers and innovators should invest more effort in facilitating teachers' positive attitudes and willingness to innovate.

I am bothered by the fact that occasionally teachers are blamed for the failure of a reform, but they are not praised when it succeeds, since it is taken for granted that they are doing what they are expected to do. Van Driel, Beijaard, and Verloop (2001) criticize those who blame teachers although they do not pay enough attention to the role of teachers as agents of change. In my study, the teachers are the ones who are supposed to use the Jeliot animation system. Since its use is not obligatory, it is important to investigate the attitudes that teachers possess towards the integration of an animation system in their instruction; without their enthusiastic collaboration the system will not be used.

2.1.7.2 Inconsistency between the enthusiastic reaction to innovation and its integration into the classroom

Another important subject that is well grounded in the literature is the inconsistency between the positive reactions of teachers towards innovations and the fact that the same teachers do not bring those innovations into their classrooms. This inconsistency can be found in: Manouchehri (1999); Cuban, Kirkpatrick, and Peck (2001); Midyan (2003); Hofstein, Navon, Kipnis, and Mamlok-Naaman (2005); Even (2005); Toprakci (2006). I found three studies that try to explain this inconsistency; for example, lack of time is one of the reasons given for this inconsistency (Cuban, Kirkpatrick, & Peck (2001); Henderson (2002); van Driel, Beijaard, & Verloop (2001)).

This is very relevant to my research. Many educators feel that animation is a good pedagogical tool; research has shown that animation really helps, and teachers who observe Jeliot or other animation systems usually show great enthusiasm. But, when it comes to integrating the animation system into the classroom, many teachers prefer not to do so. Even (2005) suggested giving more attention to the integration of tools in class; she also reports that very little research has been done on this topic.

2.1.7.3 The centrality of the teacher

Teachers have problems relinquishing their position of authority and they resist changes that might move the center of learning to the student, "reducing" the role of the teacher to that of a facilitator. I call this *the centrality of the teacher*. This is discussed in: Borko and Putnam (1996); Underwood (1997); Fullan and Hargraves (1996); Cuban, Kirkpatrick, and Peck (2001); Van Driel, Beijaard, and Verloop (2001); Stacey (2001); Elbaz-Luwisch (2001); Zbiek (2001); Manouchehri (2003); Hofstein, Shore, and Kipnis (2004)); Agudelo-Valderrama, Clarke, and Bishop (2007).

The centrality of the teacher is important in my research since I have found that teachers show anxiety towards the changes and activities that are needed to integrate an animation system in their classrooms. In fact this is one of the main reasons that teachers (implicitly) express for not using an animation system.

2.1.7.4 The reaction of teachers towards changes: attitudes, feelings

The reaction of teachers to change is important (van Driel, Beijaard, & Verloop, 2001), especially when it concerns experienced teachers who do not like changes that require them to change their *scripts* (White, 2003, emphasis mine). Hofstein, Shore, and Kipnis (2004) refer to the anxiety of teachers when faced with the changes needed to use inquiry. Cohen and Ball (2001) emphasized the fear of failure in examinations that teachers felt as a reason for not using a new curriculum. Several studies deal with the fact that beliefs and attitudes affect teaching: Borko, Eisenhart, Brown, Jones, & Agard, (1992); Borko & Putnam (1996); Trigwell (2000); Underwood (1997); van Driel, Beijaard, & Verloop (2001); Stacey (2001); Zbiek (2001); Midyan (2003); Hofstein, Shore, and Kipnis (2004); Hofstein, Navon, Kipnis, & Mamlok-Naaman (2005). Most of the studies point out reasons for failure among them: lack of time, lack of content knowledge as well as pedagogical content knowledge, fear of technology, loosing the centrality in class.

Booth and Anderberg (2005) studied teachers at the university; although this is a different population from high school teachers, even in this case they reported that teachers had problems adopting the new way of teaching. Many of the above studies explain how the attitudes and perceptions of teachers affected their accepting changes and caused innovations to be delayed or not to be implemented at all. Most of the studies suggest that people who want to bring about change must give as much attention to the attitudes of teachers as to the content of the materials.

2.1.8 Summary

Teachers are the agents who bring innovation to learning. There is an inconsistency between their positive reaction towards innovations and their reluctance to integrate them into their teaching. The literature has little information about why this is so, in particular when the innovation concerns educational technology. I found that attitudes and perceptions affect the teaching process and the teachers' decision making, especially when the centrality of the teachers is involved. I am interested in finding out the reasons that cause computer science teachers to resist the use of an animation system as a pedagogical tool.

I found that research on the subject of teachers and their connection to curricula is broad, and that many articles have been written about the fact that teachers do not use the curriculum materials, or, when they do so, they use it in ways other than those that the innovators or the authorities expected them to do so. Nevertheless, in spite of attempts to "correct" the situation, it remains the same. I think that it is only logical to expect teachers to use the materials as they understand. But it is also reasonable to let them be aware of new materials so that they could make their own decisions later.

I have also found that there are different ways that researchers use to measure the change between the enacted curriculum and the intended one, and there are even different ways to define the "use" of curriculum materials. Therefore one can study from these different ways of "using" the curriculum about what teachers know, believe, understand, etc. Studying these ways is important to innovators in order to address the teachers' needs, and possibly to increase both the "use" of the curriculum materials and the "correctness" of their use. This is one of the reasons that I am using both phenomenography (Section 3.1) and the theory of planned behavior (Section 3.2).

I have found that some of the reasons for the failure of reforms can be related to the attitudes that teachers possess towards the innovation; therefore before making a revolution, especially those that are supposed to be very expensive, there should be an investigation of the teachers' point of view. Before moving to the age of a "computer for each student," it is logical to try it on the community that already use computers as pedagogical tools as part of its practice, namely, CS teachers.

2.2 Computer Science Education

My study deals with CS teachers; therefore it is important to give a definition of what computer science is. Tucker (2003, as cited in: Stephenson, Gal-Ezer, Haberman, & Verno, 2005, p.13) defined CS as: "The study of computers and algorithmic processes including their principles, their hardware and software design, their applications, and their impact on society". It is important to give this definition since there is a tendency to limit CS to programming or to confuse it with computer literacy.

The following two sub-sections deal with the development of computer science curricula, in general, and of the Israeli computer science curriculum, in particular.

2.2.1 Development of computing curricula

One of the first published reports dealing with computing curricula is known as Curriculum '68 (Curriculum Committee on Computer Science, 1968). This document provided recommendations for four-year programs in computer science. Curriculum '68 recommended a set of courses that included computer programming, computer systems, computer organization and architecture, algorithms, data structures, operating systems, programming languages, and numerical analysis. It also recommended the study of discrete mathematics, calculus, linear algebra, and probability and statistics. (Goldweber, Impagliazzo, Bogoiavlenski, Clear, & Davies, 1997, p. 95)

This curriculum did not have any recommendations on using animation systems, but changes in technology caused changes in the curriculum. During the years there have been many publications suggesting reforms in the curriculum, the latest from 2005 (IEEE Computing Society/ACM, 2005). In the latest curriculum, we cannot see recommendations for using animation systems, but we can see that there are sections that deal with information technology.

2.2.2 Computer science education in Israel

"The Israeli education system is basically centralized. The Ministry of Education sets educational policy on all levels and implements it with help from specialized committees" (Gal-Ezer, Beeri, Harel, & Yehudai, 1995, p. 74). In 1970, a curriculum committee was established in order to develop an updated curriculum in CS. In 1999, there was a large change in the curriculum (Ministry of Education, 1999), and currently a new committee is again working on changing the curriculum. They want more computer use in classrooms (Curriculum Committee, 2008). According to the curriculum developed in 1995 and in use since 1999, computer laboratories should be "well-equipped and well-maintained." This is the responsibility of the school system. Moreover each student must have a computer for himself during the laboratory session.

We can see that there is a difference between the Israeli curriculum and the general one concerning the use of computers in classrooms.

2.2.3 Research on computer science teachers

In this section I will give an overview of research in computer science education (CSE) that focuses on teaching and teachers. The section is divided into two parts: the first deals with CSE research and the second with phenomenographic research related to CS teachers and teaching.

2.2.3.1 Computer science education research

Computer science education research is aimed at improving learning and teaching within the field of computer science. Studies in CSE were normally derived from the needs of the computer science educators of the universities, and addressed problems that were grounded in real teaching situations. Frequently the studies concerned new tools or new methods for teaching. The methodology in the field of CSE research has been dominated by psychological approaches, for example, studies that deal with the mental models of students (Yeshno, 2002; Yehezkel, 2004).

Ben-Ari (2001) argued that constructivism could inform computer science teachers about models and how they should be taught. According to constructivism, knowledge is not transferred from an individual to another in a passive way; instead, students are encouraged by their teachers to construct their own understanding in an active process. Examples of this approach can be found in: (Ben-Bassat Levy, 2001; Ben-Bassat Levy, Ben-Ari & Uronen, 2003; Ragonis, 2004).

Schofield (1995) performed extensive observations on the social effects of introducing computers into schools; this included the use of computers for teaching computer science itself. She found that computer labs modified the way in which students view the teacher. Teachers are transformed from authority figures who transmit knowledge to students into colleagues in problem solving. This is because the teachers are no longer able to answer all the students' questions, either because they lack the knowledge or because their knowledge is faulty. Instead, they frequently collaborate with students and other teachers to seek solutions to the problems that arise when using computers.

Robins, Rountree, and Rountree (2003) reviewed and discussed the literature relating to the psychological and educational study of programming. Among the studies in this review the authors cite du Boulay (1989) who described five overlapping domains and potential sources of difficulty that must be mastered by novice students and teachers.

> These are: (1) general orientation, what programs are for and what can be done with them; (2) the notional machine, a model of the computer as it relates to executing programs; (3) notation, the syntax and semantics of a particular programming language; (4) structures, that is, schemas (program as a text) /plans (programming as activity) (p. 141); (5) pragmatics, that is, the skills of planning, developing, testing, debugging, and so on. (p. 148)

Animation systems were designed specifically to facilitate overcoming the above difficulties that novices face. The dynamic view of the execution of programs that animation systems provide is able to help students understand the model of a computer.

2.2.3.2 Phenomenographic research in CSE

Other research has focused on understanding students' learning in realistic situations. Phenomenography has been used in such research, since it allows researchers to focus on the subject matter of computer science concepts and principles. Booth (1992, p.69) described the ways students in an introductory course on functional programming understood technical aspects such as correctness and recursion, as well as cultural aspects such as the nature of programming. The research question was: "What can be said about what it means and what it takes to learn to program?" The data was collected by interviewing students, by videotaping them while they were engaged in programming and by examining written work such as examinations and laboratory exercises. The data was analyzed with the assistance of a computer program, which extracted a pool of quotes. Then the quotes were assigned to themes. The researcher described the ways the students went about solving programming problems. She found three categories about conceptions on the nature of programming: (1) programming as a *computer-oriented* activity – the activity is focused on the computer; (2) programming as a *problem-oriented* activity – the main focus is on the problem and the computer is just the instrument; (3) programming as a *product-oriented* activity – the main focus is on the program as a product of the programming. The categories were accompanied by quotes from the interviews with the first year students. The product of her study was the conceptions that students have in context of programming and programming languages.

Booth (2001) described a phenomenographic study into an introductory course *Computer Science and Engineering in Context*. The study was carried out for one year and then for one more year after getting some experience. The course dealt with computer science and engineering as an interdisciplinary subject; it went beyond the classical understanding and manipulating of the world of an engineer. It was also intended to lead the students to find ways of collaborating and communicating with each other. In pedagogical terms, the course aimed not only to bring the students to use practical tools, but also to raise questions that relate to future theoretical studies and social issues.

The phenomenographic analysis produced the following three categories about the relevance of the course from the point of view of the students: (1) the course did not provide anything meaningful; (2) the course was seen as composed of its parts: computer science and engineering, but not as an interdisciplinary course; (3) the students felt that the course should have been an interdisciplinary course, but they felt that something was missing. The work in groups was also evaluated and produced the following three categories: (1) although the students worked in groups, they felt isolated within the group. The members of the group see the teachers as the experts who transmit their knowledge to the students; (2) the group was seen as whole divided into fragments that can be distributed among the group's members. The members of the group expect their teachers to play the role of judges that approve or disapprove of the solutions; (3) Learning is conceptualized as a part of a collaborative effort, and the group supports the individuals in it.

In her discussion, Booth (2001) emphasized that the *tutors were not aware of the goals of the course, and that reflected the attitudes of the students towards the relevance of the course*. In the second year the situation was changed and the tutors prepared themselves according to the goal of the course. The overall conclusion of the study was that tutors are very important to the experience that the students are supposed to acquire in the course. That was not only because they supported the practical aspects, but also because of their insight into the course, so that they could guide the students according to the spirit of the course. It is important that the tutors experience the relevance of the course by themselves in order to be able to better understand the difficulties of the student. Booth concluded that teaching should offer not only the expert point of view of the subject, and also suggested a rich variation in different ways of coming to understanding of what it means to program.

Lister, Box, Morrison, Tenenberg, and Westbrook (2004) conducted a phenomenographic study of the intentions held by computer science educators when teaching data structures. Their research question was: What are the variations in understanding that computer scientists have of the purpose of teaching data structures? They interviewed five subjects, three of whom were academics from three countries who had recently taught the advanced course, while the other two had a strong interest in the skills that the students acquire from this course. The researchers asked them to read a paper that dealt with the phenomenon and then asked them to describe and justify the way that they would have taught the subject. They used two types of sources: interviews' transcripts and relevant computer science literature. The analysis focused on the intentions the educators bring to their teaching process of data structures. They found five distinct categories as the outcome space: (1) developing transferable thinking – the process of answering is as important as the answer itself; (2) improving students' programming skills; (3) knowing "what's under the hood" – the graduate should be aware of the inside of the units they use in order to manipulate data structures; (4) knowing software libraries – use the data structures' unit libraries; (5) component thinking – the students must be able to use the black box components without programming them.

The researchers defined two dimensions of variation: one dimension is variation in the degree of abstraction from abstract to concrete: categories (1) and (5) seem to belong to the abstract level while categories (2) and (4) belong to the concrete level. The other dimension deals with computer science vs. object engineering: categories (1) and (2) were assigned to the computer science level whereas categories (4) and (5) deal with object engineering. Category (3) was more concrete than abstract but could not be assigned to computer science or object engineering. The researchers said that they did not mean to judge the educators' intentions in teaching data structures by saying that one category is better than the other is, therefore they did not give any hierarchy of those categories. Moreover they thought that the community should be aware of the specific categories before moving to more specific issues. They claimed that the phenomenographic research style was responsible for creating awareness of new categories that were unknown before the study.

2.2.4 Summary

The studies on teachers' attitudes show that there is a difference between teachers who use technology in their lessons and those who don't, and that this capability gets better with experience. Lack of experience may influence the ability to integrate technology in the classroom setting and even cause some teachers to reject it. Computer science teachers are presumably more experienced than other teachers in their use of technology, although this may be an unwarranted assumption. CS teachers are expected by the community to be 'technologists' and this affects the demands from them. This may lead to frustration of the CS teacher who is not as technology-oriented as he/she should be, and who has problems in employing an animation system. CS teachers usually do not *express* this frustration that I believe exists, so I found some evidence of this feeling in the context of choosing to integrate an animation system in CS lessons. Zibek (2002), who pointed out the teacher-centered presentation and the change of the teacher's role in class, supports another hypothesis that I will suggest: that teachers are afraid to lose their central position in class.

I believe that teachers who use an animation system as a pedagogical tool must possess all the three attributes that Shulman (1986) defined: (1) Teachers must be aware of the way an animation system presents the subject matter; (2) Teachers must be aware of relevant case studies in order to use them with the animation system and they must know how to integrate the use of animation in the teaching sequence; (3) Teachers must use strategic knowledge to confront problems when using an animation system in class. The importance of PCK was mentioned also by Booth (1997) and by Marton and Booth (1997, p. 85) when they referred to the "what" and "how" in the learning process. The phenomenographic study shaded light on the ways that teachers project their strategic knowledge. The pedagogical reasoning cycle led me to realize that in order to get a better understandings of the teachers' attitudes towards the use of animation, I should observe and interview the teachers while preparing to use animation in class, not only during class.

The studies on computer science teachers confirmed my intuition that the teachers have a major role in the learning situation in the classroom. Moreover, the study of Schofield (1995) strengthened my belief that the teachers have to experience the use of an animation system before they use it in class, because, as I pointed it out in my MSc. thesis (Ben-Bassat Levy, 2001), understanding animation is an acquired skill and this takes time. The study of Trigwell (2000) confirmed my attitude about how educators see the process of teaching, and I can use the expected variation he found to help me design the interviews. The study conducted by Lister, Box, Morrison, Tenenberg, and Westbrook (2004) made me consider another point of view: the purpose of teaching. The two studies conducted by Booth (1992; 2001) have taught me the phenomenographic tradition, in particular, that the awareness of the goal of the course directly affects the students.

In her study, Booth (2001) concluded that the tutors had a significant influence on students understanding the goal of the course. Trigwell (2000) introduced two extremes in teaching attitudes, one is teacher as a center and the second focuses on the student. These different focuses influenced the teaching process in class. Those studies, together with some pilot interviews with teachers, led me to the belief that teachers hold a strong view of the *centrality of their role in the teaching process*. That is, they regard themselves as experts in explaining the subject matter, and do not believe that an animation system can materially contribute to learning.

Subsequently, I was able to interpret the findings of Scholfield (1995) and Tirosh, Even, and Robinson (1998) within this concept of centrality: they describe the important role of a teacher as an explainer. Yackel (2002) emphasized the teachers' central role in inquiry mathematics classrooms, and claimed that effective teachers are those who are aware of the subject matter and of their students' conceptions. It is not enough to know the subject matter, teachers must have something more, and therefore they have a central role in the class situation.

From this review several questions appeared: (1) How do teachers use their own knowledge in order to use an animation system as a pedagogical tool? (2) What is the difference between CS teachers and teachers from other disciplines? (3) How do teachers find an animation system with respect to their role in class? (4) How do the beliefs, attitudes and expectations towards the use of an animation system affect the teachers' integrating an animation system in their classes?

2.3 Educational Technology

2.3.1 Educational technology in the context of my study

For the purpose of my study, educational technology means using software tools for educational reasons. These tools do not include generic tools like the Internet and presentation software (PowerPoint).

2.3.2 Introducing technology and educational technology into the classroom

Introducing computers into classrooms is not a new topic. Many reforms that tried to introduce computers into classes failed, and the reasons for these failures are well known in the literature. One of the ideas that innovators have about dealing with these unsuccessful trials is that if teachers get the appropriate education and training in using computers and technology software, they would easily adopt them and use them in their classes. Moreover, I have read articles (Cuban, 1986; Kaput, 1998; Czerniak, Lumpe, Haney, & Beck, 1999; Kaput, 2000; Harari, 2004; Guzdial, 2006) that claim that in the future all activities in class will involve computers.

For example, there is a system called Simcalc (Kaput, 2000); the author studied the idea of using computers and networks in classrooms, where in the future classroom, the teacher has a computer and the students have calculators that can be controlled by the teachers. He said that the benefits of using such a classroom system can be found only after employing it in the classrooms.

Rogers (2003) claimed that:

> Many technologists believe that advantageous innovations will set themselves, that is, the obvious benefits of a new idea will be widely realized by potential adopters, and that the innovation will diffuse rapidly. *Seldom is this the case*. Most innovations, in fact, diffuse at a disappointingly slow rate, at least in the eyes of the inventors and technologists who create the innovations and promote them to others. (p. 7, emphasis mine)

I think that the above vision and beliefs are very expensive. In order to make such a transition in classrooms without checking it on a large population is very risky. But this testing may be facilitated by studying CS teachers. I agree with Rogers that innovations do not get accepted by themselves.

Here we can see an example on how just spending money on technology is not enough. Blin and Munro (2008) say that "although technology is now common place in most higher education institutions – most institutions have invested in a virtual learning environment (VLE) and employ staff dedicated to supporting e-learning – there is little evidence of significant impact on teaching practices and current implementations are accused of being focused on improving administration and replicating behaviorist, content-driven models" (p. 475).

2.3.3 Teachers' attitudes towards the use of software tools

Investigating high-school teachers' attitudes towards the use of software is not new, but the experience of CS teachers has never been discussed. I have found only one report that refers to this subject, although it does not investigate it:

> The second major obstacle to visualization technology identified in our survey, instructor overhead, is *not directly addressed in this report.* However, if experimental results show that some forms of active engagement with visualization lead to very positive educational outcomes, we are hopeful that a variety of educators will begin the development of instructional materials that take advantage of those forms of engagement. (Naps et al., 2002, p. 132, emphasis mine).

The study dealt with educators in universities (not high school teachers), and the report summarizes the advantages and the disadvantages that educators listed. The main advantages were the beliefs that animations help students understand topics in CS, that the use of animation makes teaching more enjoyable, that the animation provides a base for discussion in class, etc. The main disadvantages were concern with the time that it takes to install a visualization system, the time that it takes to transition animation into classrooms, the lack of information about the benefits that animations have on the students, the fact that using animation needs a dark room, etc.

There is a very interesting quote of *one* respondent that I found in the report:

> Another respondent is convinced that the most profound reason colleagues do not use dynamic visualization is a personality characteristic that permits one teacher to engage in high risk behavior such as using children's toys as instructional props. This respondent observes that some educators feel it is very high risk to engage in this sort of extravert activity. (p. 140)

I think that this is connected to the centrality point of view that I found with many teachers, and with the fact that only one respondent said it. This is also connected with the dissonance that I found that some teachers have. This anecdotal response does not mean that few educators possess that attitude, only that it is not politically correct to say so explicitly. This is the reason that the dissonant way of experiencing is the most difficult to discover. The phenomenographic phase in my study found very similar reasons for not using animations.

TPB has been applied to educational studies on teachers' beliefs about using educational technology in the science classroom (Czerniak, Lumpe, Haney, & Beck, 1999). The conclusion of this study was that: "Educators should examine teachers' beliefs before planning classes, workshops, or seminars. Restructuring efforts should consider teachers' concerns about software materials, funding, supplies, time, and support structures. Failure to do so may prove to be unproductive in terms of time and money" (last paragraph). This study was conducted on teachers of grades five to eight. These teachers were selected randomly from the district directory. The teachers were asked to answer a TPB questionnaire about their beliefs about using educational technology such as TV, computers, video, and printers. The results showed that the teachers perceived behavior control was low while their attitudes towards the behavior were high.

Another TPB study was carried out by Ma, Andersson, and Streith (2005) who studied student teachers' perceptions of computer technology in relation to their intention to use computers. The purpose was to shed light on more effective ways to motivate the use of computer technology in schools. This study also described a situation where teachers took courses on how to employ computers into their classrooms, but the bottom line was that they did not bring it to their classrooms. This behavior was a result of the perceived usefulness of using the computers and perceived ease of using them. The problems that were related to those two key factors seem obvious and existed for a long time without effectively being tackled.

The above two articles deal with teachers who were asked to use computer technology in their classes. The teachers in that study were not CS teachers. These two studies support my belief that CS teachers' perceptions and beliefs should be studied, since the above studies claim that—in spite of the fact that teachers participate in courses that should give them a better knowledge on computers and technology—they still feel that they are incapable in bringing technology into their classrooms.

I found an article that supports the fact that teachers do not change the way they teach (Tan & Forgasz, 2006). In their article there is a citation from Burrill et al. (2002) who found that "teachers generally use handheld graphic technology as an extension of the way in which they have always taught" (p. iv), and that they way they teach is influenced among other things by their knowledge and beliefs. The study conducted by Tan and Forgasz compared the teachers' point of view about using graphic calculators between teachers from Singapore and teachers from Victoria, Australia. The authors present the different contexts: the use of calculators is mandatory in Victoria and voluntary in Singapore, and the perceptions of the skills needed from Victoria teachers were higher than those of Singapore. The access to calculators was also different: while all teachers from Victoria had access, only 72.7% of the teachers from Singapore did. The modes of teaching were different, too. Since the examinations in Victoria included calculators, the teachers used mostly the modes needed for those exams. The total number within each mode of teachers from Singapore was less than the teachers from Victoria. When teachers were asked about the usefulness of the calculators, Victoria's teachers were more positive than Singapore's teachers.

When I compare the previous study in 2002 and the current one, it can be seen that the point of view of the Victoria teachers changed to be more positive than it was before; this can be seen also when we compare their perceptions with those of Singapore teachers. The authors suggest that it is grounded in the mandatory use of the calculators.

Briscoe (1991) described the situation of teachers not introducing new techniques into their classrooms in spite of their willingness to do so. She conducted a case-study research and found that there was an inconsistency between the role of the teacher as he/she perceived it (as a performer) and his/her own belief that meaningful learning is achieved by students dealing with problems by themselves. Briscoe describes the normative beliefs held by the teacher and the impact those beliefs had on his choosing a traditional way of teaching. Another assertion was that the teacher was unable to personalize his vision on the ideal class and his role as a teacher in it. The author claims that the images, beliefs and metaphors that teachers hold are the result of many years of experience in schools as students and as teachers, and these beliefs cannot be changed with words alone (p. 198).

The study conducted by Briscoe is a good example why we need both direct and indirect measurements. The difficulty was described by (Ajzen, 1991), but the examples that he gives do not deal with teachers. Ajzen states that people usually find it easier to give a probabilistic description of their attitudes or beliefs (indirect measurement) than accurate ones (direct measurement). Another idea that I have found in this article is their attempt to give an explanation of the centrality point of view that makes teachers be reluctant to use animations in class.

The Technology Acceptance Model (TAM) was developed by Davis (1986; 1989). In TAM, there are two beliefs focused on information system acceptance: *perceived usefulness* and *perceived ease of use*. Perceived usefulness was defined as the degree to which a user believes that a specific system could increase his/her performance at work. As long as he/she thinks the system might help in some way, the attitudes they express will be positive. Perceived ease of use was defined as the degree to which user thinks a specific system is easy to manipulate in order to take advantage of the functionality of the system. As long as the users think that is easy to use the system, their attitudes will be positive and affect their behavior further (Davis, 1989, p. 320).

TAM is concerned with using computers in the business world and not in education; this can be seen from the questionnaire that Davis developed (Davis, 1989. p. 324; Davis, Bagozzi, & Warshaw, 1989. p. 990).

This study is different from what I need in mine, since I am using a special kind of technology – an animation system – and not information systems. The second difference is grounded in the fact that I am interested in the perceived behavior *control* that emphasizes the controllability and *centrality* that is very important for teachers. In his study, Davis observes information systems in general, and therefore his questionnaire is focused on these aspects. My questionnaire was built according to the TPB instructions.

The study closest to mine was the one conducted by Ngai, Poon, and Chan (2007). They used the TAM model to examine the adoption of WebCT (web courses tools) that was designed to support an e-learning course. They found that if technical support is given then it increases the use of WebCT by students. But, again, this is not compatible with animation systems that are used for teaching.

2.3.4 Summary

The literature review supports the rationale of my study. The vision of the future class is as a class that contains a computer for each student and where all the communication in class will be through using computers. I have found studies that showed that teachers need to study to use computers, and even if they have positive attitudes towards the use of computers in class, they do not employ them into their classes. In spite of the beliefs that some researchers have that we will only know about something after we will try it, I think that the trial will be easier if CS teachers are studied first. CS teachers as a group use computers more than any other teachers. They are trained to do so, and they employ software in their classes. Nevertheless, when dealing with animation systems, even CS teachers do not always employ them in their classes. Therefore, studying this group is easier than making a revolution that may cost a lot of money, and, even more importantly, studying why they do not use animation systems may shed light on problems that innovators who view the future class as computerized have not yet thought about.

Naps et al. (2002) reported on attitudes of students towards the use of animations in education. The group also described a survey of university educators and quotes the benefits and the drawbacks that educators listed in the survey. This report reinforces my idea that high-school CS teachers should be studied; moreover I found an evidence for the dissonant category of the phenomenographic study that preceded the TPB phase. This is the only study that I have found that is somehow dealing with the attitudes towards the use of animation systems, but it deals mostly with students and only partially with university educators.

2.4 Animation Systems

Algorithms, which are the blocks that programs are built from, are very abstract. Therefore, programming and algorithms are hard subjects to teach and study, especially for novices, since they are inexperienced and they have not yet developed the ability to analyze a problem in order to write a program that solves it. Teachers have employed many ways to help students acquire new knowledge in these fields. Teaching methods have varied from illustrations on the blackboard through animation systems. "Animation systems—software tools that can show a dynamic view of the execution of a program—were designed to help novices improve their understanding and to help teachers facilitate learning" (Ben-Bassat Levy & Ben-Ari, 2007, p. 246).

2.4.1 The Jeliot animation system

Jeliot is an animation system that was designed especially for novice students of programming (in Java) (Ben-Ari, Myller, Sutinen, & Tarhio, 2002). This animation system is the result of long term collaboration between the Weizmann Institute of Science and the University of Joensuu in Finland. The user interface is very simple and consists of one window split into two main panels: The left panel displays the source code that is being animated, while the animation takes place in the right panel. The lower part of the right panel includes areas for creating constants and for displaying the output generated by the program. The VCR-like buttons below the source code control the execution of the program animation. Figure-2 is a screenshot of Jeliot during animation:

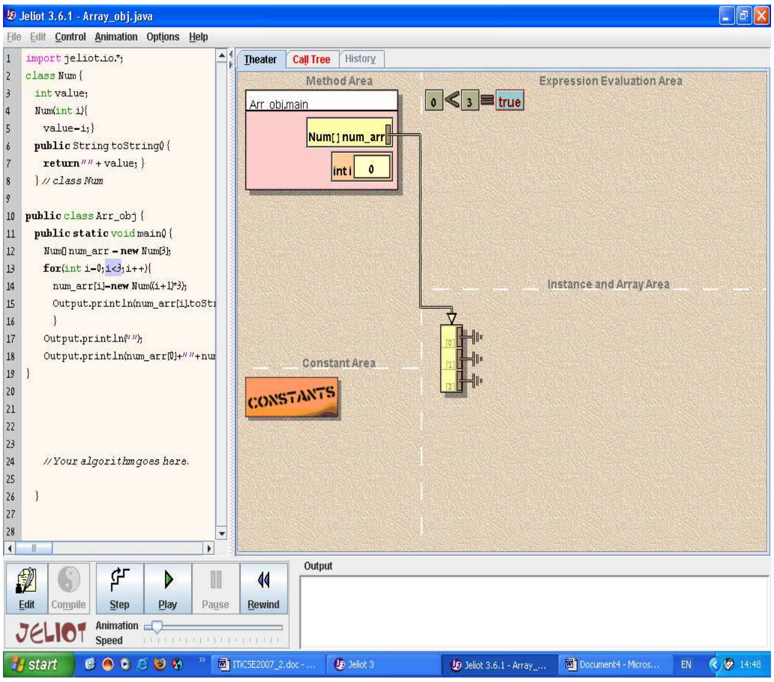

Figure-2 A screenshot of Jeliot

A year-long study of the effect of Jeliot on the learning of novice students produced encouraging results (Ben-Bassat Levy, Ben-Ari, & Uronen, 2003). The students used the vocabulary suggested by Jeliot for explanations, and they showed a better understanding of the execution of statements than students who did not use Jeliot. A follow-up study showed that Jeliot improved the attention-directing characteristics of the students, adding another justification for using animation (Ebel & Ben-Ari, 2006). The Jeliot animation system has been developed as a part of a long term of research; this can be read in detailed in Ben-Bassat Levy and Ben-Ari (2009).

The Jeliot animation system was selected as a finalist for the 2007 Premier Award for Excellence in Engineering Education Courseware.

2.4.2 Research on the effect of using animation systems on students

2.4.2.1 Animation as a pedagogical tool in CSE

For the past two decades, research on animation systems as pedagogical tools has been an active field of study, attempting to enhance CSE in a variety of ways (Hundhausen, Douglas & Stasko, 2002). For example, animation systems have been used to help teachers illustrate algorithms in class. They claimed that despite its intuitive appeal as a pedagogical tool, algorithm animation has failed to catch on in mainstream CSE. Moreover, they emphasized that the majority of CS teachers prefer to use traditional teaching methods, such as blackboards, whiteboards and projectors. Several reasons for not using animation in class were presented: (1) teachers feel that they don't have the time to learn an animation system; (2) teachers claim that the use of an animation system in class would consume time which they don't have; (3) teachers complain that the use of an animation system would require too much effort from them; (4) teachers are afraid that the use of an animation system in class would not be effective. The researchers pointed out that reasons (1)-(3) were exactly opposite to the reasons for using the animation systems given by their developers!

Hundhausen, Douglas and Stasko (2002) conducted a meta-study in order to better understand the effectiveness of animation technology. They defined effectiveness as "to what extent does the algorithm visualization artifact assist the individual or group in fulfilling the objective? (e.g. 'learn how the target algorithm works')." They summarized 24 studies and obtained equivocal results: Eleven of the studies yielded statistically significant differences between two groups, the group that used the animation system and a control group that did not use it or used an alternative one. Ten of the studies did not produce a significant result. Two studies found significant results, but the contribution of the animation system to the results were uncertain. One study yielded a negative result: the animation group performed worse than the control group. The researchers drew the following conclusions: (1) the way students used the animation system (*how*) had a greater impact on educational effectiveness than *what* they saw while using the animation system; (2) studies that used pre- and post-tests must address the methodological issue, that an intervention always occurs between pre- and post- tests; (3) the use of an animation system was effective when it was used actively by the students in class.

Petre (1995) (see also Petre and Green (1993)) studied the difficulties in reading visual displays in the field of software visualization. She found that there was a difference in the readership skill between novices and experts. That difference was characterized by the experts' skill in reading the *secondary notation* encoded inside the displays. The secondary notation is the layout, coloring or any implicit property of the display. The experts were able to use this information when solving problems, but novices seemed to miss that extra information and thus failed in solving the problem. Those results indicated three issues that should be taken into consideration when designing visual displays. Firstly, novices need different kinds of visualizations than do experts. Secondly, visualizations for novices should be as consistent as possible and make the secondary notation as explicit as possible. Finally, novices must be taught how to read the visualization display. They concluded that understanding graphical representation is an acquired skill.

During the school year 1998-1999, I taught a course (three hours a week for the whole year), which used the animation system Jeliot 2000 (Ben-Bassat Levy, 2001; Ben-Bassat Levy, Ben-Ari & Uronen, 2003). Jeliot 2000 is a program animation system intended for teaching introductory computer science to high school students. The goal was to help novices understand basic concepts of algorithms and programming like assignment, I/O and control flow, whose dynamic aspects are not easily grasped just by looking at the static representation of an algorithm in a programming language. In Jeliot, the idea is to involve the students in constructing their own programs, and at the same time engage them in examining a visual representation of their program's execution and developing their program further (Myller, 2004). During this process they acquire a mental model of computation that helps them to understand the constructs of programming. Furthermore, the model can be used to acquire new knowledge and the vocabulary used to discuss programs and programming concepts. Thus, the students are engaged with the tool and are learning by doing and by constructing new knowledge in a constructivist way (Ben-Ari, 2001).

The study compared the performance of two groups, one of which used the Jeliot animation system and the other which did not. Every new CS concept in the introductory course was taught in both groups and then an in-class paper-and-pencil assignment was given as a pre-test. Afterwards, the animation group used Jeliot in order to predict the outcome of a program fragment, while the control group used Turbo Pascal in order to predict the outcome of the same program fragment; then another in-class paper-and-pencil assignment was given as a post-test. The pre- and post-tests were composed of questions designed to test the students' understanding of CS concepts that they had learned. Following that, an interview session was carried out, in which the students were asked to solve a problem, verbalizing their thoughts as best they could. At the end of the year, an additional assignment was given in order to evaluate long-term learning. Finally, a follow-up assignment during the next school year was used to investigate if any effects could be discovered that lasted beyond the use of animation in a single course.

I concluded that, even in long-term use, animation did not improve the performance of all students: the strongest students did not really need it although they enjoyed playing with it, and the weakest students were overwhelmed by the tool, although their grades were not harmed. But, *for many, many mediocre students, the concrete model offered by the animation made the difference between success and failure*. Only after the third assignment was there significant improvement in the grades, leading me to conclude that animation must be a long-term part of a course, so that students could learn the tool itself. I found it particularly significant that the animation group used a different and better vocabulary of terms than did the control group. The follow-up assignment revealed another attribute: The animation group performed better than the non-animation group in explaining a new concept that was taught a year later, meaning that the animation effect was long-lasting.

An ITiCSE Working Group (Naps et al. 2002) raised the issue of the effect that animation systems have on students and teachers. The Working Group report summarized the advantages and the disadvantages of using visualization tools. The advantages include: they help students understand topics in CS; they make teaching more enjoyable; they facilitate discussion in class. The disadvantages include: the time it takes to install software tools; the effort required to introduce the tools into the teaching practice; the lack of information about the benefits for learning.

2.4.3 Summary

The studies on animation and CSE emphasize that animation systems can be effective educational tools. Teachers must choose an animation system after carefully analyzing the requirements of the subject and the target students. Furthermore, the teacher should be aware of the methods he/she uses, because they might be the reason for the equivocal results achieved in those studies. Moreover, the teacher has to consider the goals of the course before using the animation and only then can he/she use the appropriate method.

2.5 Social Psychology

The categories that resulted from the phenomenographic analysis refer to *populations*, but it became clear to me that the behavior of the teachers was based upon their *attitudes as individuals*. This was particularly apparent in those who rejected the use of the system. Therefore, I decided to supplement the phenomenographic research with research using a different methodology that would be more appropriate for investigating individual attitudes and behavior. The branch of social science that deals with attitudes and behavior and the connection between them is *social psychology*.

2.5.1 Attitudes

There are many studies on attitudes, but the definition of attitudes is not the same in all the studies. For example: "The term attitude encompasses a wide range of affective behaviors (e.g., prefer, accept, appreciate, and commit) and is due too loosely and without basis by some writers. It is also applied in a number of contexts and with a variety of meanings, which has led to considerable confusion. Nevertheless, a distinct, yet complex definition of attitude, is emerging within the literature" (Kobella, 1989, second section, first paragraph).

Here are three more of the many definitions of attitudes: (1) Attitudes can be defined as "lasting, general information of people, objects, or issues" (Petty & Cacioppo, 1985, as cited in Baron & Byrne, 1987, p. 116). *Lasting* means that the attitude tends to persist across time. *General* means that it involves abstraction. (2) Most psychologists accept the ABC model of attitudes, which means that an attitude has three components: Affect, Behavior, and Cognition (Breckler, 1984, as cited in Baron & Byrne, 1987, p.116). The *affect* component refers to positive or negative emotions about something; the *behavior* component involves intentions to act in certain ways; the *cognition* component refers to the thinking about and interpreting the situation that leads to form an attitude or to use an attitude (Baron & Byrne, 1987). (3) A more popular way to define attitude is given by Booth-Butterfield (2004): an attitude is "a person's evaluation of an object of thought" (Chapter 2). I think that these definitions are related since evaluation of a situation by human beings is done according to emotions about the situation, and the behavior is the result of these emotions. Only then, is a cognitive evaluation made.

In the following subsections, I write about how attitudes are formed, how they can be changed, and, finally, how attitudes and behavior are related.

2.5.1.1 How attitudes are formed

Research suggests that individuals acquire attitudes passively or actively (Baron & Byrne, 1987, p. 117). The *passive way* is a part of the socialization process by which a person becomes a member of society. It involves observations, modeling, getting positive or negative responses for doing something, and associations. Forming attitudes in an *active way* is by direct experience. This means that people form attitudes as a result of their own experience. For example, the attitudes about the career of a little girl may be influenced by the career of her mother; this is a passive way that employs the modeling of a mother to her daughter. For an example of an active way, consider someone who is sick and goes to see the doctor. If the doctor listens to the patient and tries his/her best to help him, the patient will form good attitudes towards the doctor. If another sick person will get bad treatment and the doctor will act impatiently to him then this patient will form bad attitudes towards the doctor.

CS teachers form attitudes towards the use of an animation system as a pedagogical tool the first time they are exposed to it. These attitudes depend upon the presentation and the current needs of the teachers. Attitudes and needs will be discussed later in the report.

2.5.1.2 Changing attitudes

When someone is trying to influence one to change her attitudes it is called *persuasion* (Baron & Byrne, 1987, p.124). This can be achieved by the *central route*, such as by providing convincing arguments. For example, an advertisement about using toothpaste can persuade by noting that is recommended by dentists since it has good qualities for the gums. The other way, the *peripheral route*, is trying to convince another person by using implicit methods, such as implicit advertisement. An example of the peripheral route is giving lessons in class on dental health using the toothpaste of a certain company. The toothpaste in this example is a *cue*. Persuasion can sometimes be rejected if the subject feels that someone is trying to change his/her beliefs and thoughts.

I am trying to understand the teachers' attitudes towards the use of an animation system so that we will not have to change their beliefs; changing beliefs is harder than forming them.

2.5.1.3 Cognitive dissonance

Cognitive dissonance is an unpleasant feeling caused by conflict between one's thoughts and actions (Baron & Byrne, 1987, p. 132). For example, eating a chocolate cake when one is on a diet might cause cognitive dissonance. People usually do not like to be in a state of cognitive dissonance, so they change either their attitudes or their behavior. For example, claiming that eating a chocolate cake occasionally cannot harm the diet (changing attitude), or stopping the diet (changing the behavior). Another way to reduce dissonance is by getting more information that supports one's attitudes or one's behavior. This information usually reassures the person that the inconsistency between the attitudes and the behavior is acceptable. For example, one might look for formerly fat people who were on a diet and yet they eat a chocolate cake from time to time. The third way is to minimize the importance of conflict, for example, by claiming that there is nothing wrong in eating a chocolate cake from time to time.

In my study (see Subsection 4.1.2), the teachers from group B, showed negative attitudes towards the use of Jeliot in class, already from the time when they were first introduced to it. This group of teachers faced the feeling of cognitive dissonance when they realized that they did not understand the concept of constructors in Java, and that Jeliot helped them "see" what happens inside the computer. This situation led me to the idea of connecting attitudes and behavior; since these are topics of social psychology, I turned to that discipline for the next phase of my research.

2.5.2 Behavior

2.5.2.1 Attitudes and behavior

Ajzen and Fishbein (1977) (as cited in Baron & Byrne, 1987, p.141) reviewed considerable research on attitude and behavior (the *A(attitude)-B(behavior)* problem); they found that attitudes and behavior are not necessarily consistent. For example, someone who knows that cigarettes are bad for health may continue to smoke. The researchers concluded that specific, narrow, and precise attitudes can predict behavior, as opposed to general or global attitudes. This conclusion means that those attitudes should be available and relevant at the moment (Booth-Butterfield, 2004). Available means that the attitude is at the forefront of one's mind at the appropriate moment. Relevant means that it applies to the specific situation. For example, in order to make an attitude about smoking available, one can mention that a new cigarette is being sold in the markets. To make the attitude relevant, one person can offer a cigarette to the other.

By presenting the animation system to the CS teachers, I made the attitude available. The relevance of the attitude was obvious when the use of the Jeliot animation system helped the teachers understand a complex topic.

2.5.3 Making a change

Booth-Butterfield (2004, chapter 3) says that we have to change attitudes in order to influence behavior and then worry about the way that people will use the attitude. In order to change attitudes, one should be aware of two types of thinking, *systematic and heuristic*. A person who employs the *systematic* way of thinking is very careful and makes efforts to understand; therefore, he/she usually needs facts or evidence. *Heuristic* thinking is characterized by skipping from thought to thought; people who use this type of thinking way will be easily influenced by attractions such as beautiful women wearing a new perfume. People are most of the time heuristic thinkers, since they are too lazy to be careful in their thoughts. A person could employ both types of thinking at different times for different situations. However, systematic thinkers who changed their attitudes will not change them rapidly, since they have obtained all the answers to their questions. In this case we could predict the behavior of the person.

Booth-Butterfield (2004, chapter 3) uses the terms *source* and *receiver*. The source is the one who is trying to persuade the receiver. If the source wants to achieve a persistent change of attitudes so that the receiver will not change his/her attitudes frequently, the source needs the receivers to be systematic thinkers, and these thinkers need arguments to change their attitudes. To produce good arguments, the source must understand the receivers and be able to think the way they do. Irrelevant arguments will not produce the needed shift.

But since we know that most people are heuristic thinkers, the use of cues is advised. Cues are things that attract our attention; we do not have to use careful thought to understand them. There are six cues (Chapter 3): (1) *Comparison*: when you say that something is better than something else; this is the most common cue and something that every one does. Only a few people will resist this. (2) *Liking*: when you like the source, you will do everything for him. (3) *Authority*: when the source is an authority, you can rely on what he/she says or does. (4) *Reciprocity*: when someone gives you something, you should give something back. (5) *Commitment/Consistency*: when you take a stand, you should be consistent. (6) *Scarcity*: when something is rare, it must be good.

2.5.3.1 Model for changing attitudes—the "transtheoretical model"

Booth-Butterfield (2004) suggests a model for changing attitudes: "This model says that people are in one of five different stages" (Chapter 5). The source must be aware of the stage that the receiver is in so that he/she can approach him/her. The five stages are: (1) Ignorance: the receiver does not know any thing about the issue. (2) The receiver has a preliminary idea. (3) The receiver makes his/her first moves towards change, but he/she must make the needed preparations first. (4) The first trial. (5) The change has been made and it is like a habit now. The source must be aware that the receiver cannot skip any of the stages and that each stage takes its time.

2.5.4 Summary

We have numerous attitudes and we use them all the time (Baron & Byrne, 1987). Attitudes enable us to evaluate our experience. Each attitude is made up of thoughts that are associated with feelings and behavioral patterns. Attitudes are created during socialization when people are taught to associate bad or good feelings with certain actions. Attitudes are created also when people are rewarded or punished for doing something. Adults form attitudes spontaneously on their personal experience. Attitudes and behavior are not consistent all the time. Cognitive dissonance appears when there is inconsistency between attitudes and behavior.

Research show that there is consistency between attitudes and behavior, especially when the attitudes are relevant and available, and when they are personal. Systematic thinkers can be influenced to change their behavior when the source gives them answers; these receivers' behavior is easily predicted. According to the model of changing attitudes, it is quite clear that change consumes time and that the receiver has to go through all the stages. People who are heuristic thinkers need to have a different way of influence such as the use of cues.

2.5.4.1 Implications of the literature review on teachers accepting changes

Teachers are first of all people, and it was mentioned earlier that they do not like change. There are studies that show that teachers do not like to change, but there is little information about the persistence in teachers' employing changes even ones that they have just performed (Even, 2005). We can find teachers taking courses intend to change their behavior in areas like curriculum, assessment, and pedagogical methods. For example, teachers can study how to use an animation system in class. These teachers attend the course and even seem to be excited about it, but they do not use it in class. I was able to categorize the ways of using the animation system in the course, and the reaction of teachers towards it, but few teachers started to use it in class.

The Theory of Planned Behavior from social psychology predicts behavior from attitudes and is appropriate for my research. It will be described in greater detail in Section 3.2.

3. METHODOLOGICAL FRAMEWORK

I used the qualitative research methodology called *phenomenography* for research question 1. The second research question necessitated a new methodology and for that I chose the quantitative methodology from social psychology called the *Theory of Planned Behavior (TPB)*. This was followed by an integration of the results from the two methodologies.

3.1 Phenomenography

3.1.1 What is the meaning of phenomenography?

"The word is composed from two roots: phenomenon and graph. Phenomenon comes from the Greek verb *fainesqai* that means *to appear*; this verb is originated from the verb *fainw*, which means to discover" (Kroksmark, 1987, as cited in Marton & Booth, 1997, p. 110). Phenomenon describes something in the world, concrete or abstract, which can be delimited from the world according to the researchers' knowledge of the world (Booth, 1992, p.53). "Graph is rooted in the Greek verb *grafia*, which means *to describe in words or pictures*. The composed word phenomenography means the act of representing an object of study as qualitatively distinct phenomena" (Kroksmark, 1987, as cited in Marton & Booth, 1997, p. 110).

3.1.2 The path of phenomenographic research

In this paragraph I give an overview of the phenomenographic method; every concept will be explained later in this Section.

Phenomenography is a research approach that focuses on the qualitatively different ways that people experience, understand, perceive or conceptualize a phenomenon (Marton, 1986). The basic idea of this approach is that the number of qualitatively different ways of experiencing a phenomenon is limited. The common method that phenomenographers use in order to collect data is to interview a small number of subjects. The interviews are recorded, transcribed and analyzed to reveal the variation in experience. To achieve this goal the phenomenographer tries to find one or more dimensions of variations, that is a set of categories that have a relationship among them, linearly or hierarchically; this is called the *outcome space*. It depicts the different ways in which certain phenomena are experienced and gives the relationship among them. Phenomenographers continue to collect data until they feel that they have reached the point that more data does not contribute to the identification of new categories. While collecting the data and analyzing it, the phenomenographer has to be aware of the validity of the study, which means the applicability of the results of the research to the real world. In addition, a reliability check of the phenomenographic research is done - a second researcher must confirm the researcher's decision of matching categories and quotes. If they don't agree the researcher must make changes in relating quotes to categories.

3.1.3 The evolution of phenomenography

Phenomenography as a research approach grew out of investigations into students' experience of learning led by Ference Marton at the Department of Education and Educational Research at the University of Göteborg in the mid-1970s (Booth, 1992, p. 46; Marton & Booth, 1997, p. 112). The study focused on the ways the students dealt with their studies (Booth, 1997). The questions asked related to the connection between those activities and what they learned or possessed (Säljö, 1975, as cited in Booth, 1992, p. 47). Svensson's study (1976, as cited in Booth, 1992, p. 49) analyzed how students describe their approach to learning. He grouped individuals in an outcome space of two sets of categories and found a relation between them. Booth (1992, p. 47) stated that "the *categories of description* of qualitatively different ways of understanding, the *outcome space* of these categories, and the *logical structure* between and within its components" are the most important ideas that were developed from the work of Svensson.

Later, phenomenographic research was used to investigate teaching (Lybeck, 1981, as cited in Booth, 1992, p. 49). The results showed that the teacher must look at the curriculum as a whole and then choose a method to present it. The teacher sees the learning action from the eyes of the student.

Booth (1997) defined *learning* as coming to an understanding of curricular content as a result of various activities; for example: reading or solving problems. Two very important intertwined aspects of learning are "what" and "how." "What" deals with the content of the learning task while "how" concerns the learning activities themselves. According to phenomenographic approach learning is shifting from not being able to do something to being able to do it as the result of some experience. Booth saw learning as applied phenomenography because the phenomenographer is a learner. She said that the work does not stop at the stage of mapping ways of experiencing into categories, and that one is expected to go further with the results in order to improve the learning process (Booth, 1992, p. 51).

Booth (1992, p. 52) stated that in order to understand the phenomenographic approach one should realize that it is not psychology that treats a person and his/her behavior separate from the world he/she lives in. It is not "mentalist," treating cognition and cognitive acts separated from the one who lives according to them.

3.1.4 What is "a way of experiencing something?"

Here are several citations concerning how a "way of experiencing" is defined:

> The aspects of the phenomenon and the relationships between them that are *discerned and simultaneously present in the individual's focal awareness* define the individual's way of experiencing the phenomenon. ... The key feature of the structural aspect of a way of experiencing something (and thereby also of the referential aspect with which the structural aspect is intertwined) is the set of *different aspects* of the phenomenon as experienced that are *simultaneously present in focal awareness*. (Marton & Booth, 1997, p.101, emphasis mine)

> A way of experiencing something reflects a simultaneous awareness of *particular aspects* of the phenomenon. Another way of experiencing it reflects a simultaneous awareness of *other aspects or more aspects or fewer aspects* of the same phenomenon. (Marton & Booth, 1997, p. 107, emphasis mine)

> We may not have identified the most typical or the most advanced way in which a person can experience the phenomenon, and we may not have described a generalizable distribution of the different ways of experiencing it, but we may still very well have identified the variation in terms of which we can characterize the *different ways* the phenomenon appears to the particular person in *different situations* or different ways it appears to other similar groups. (Marton & Booth, 1997, p. 128, emphasis mine)

> Conceptions and ways of understanding are not seen as individual qualities. Conceptions of reality are considered rather as categories of description to be used in facilitating the grasp of concrete cases of human functioning. Since the same categories of description appear in *different situations*, the set of categories is thus stable and generalizable between the situations even if *individuals move from one category to another on different occasions*. (Marton, 1981, p. 177, emphasis mine)

> The same person may have *different ways of experiencing* the same phenomenon at *different times* when he/she focuses on and discerns different aspects of the phenomenon. (Pang, 2003, p. 150, emphasis mine)

From these citations it is clear that a specific way of experiencing a phenomenon exists when the individual is focally aware of one aspect or simultaneously aware of several aspects of it.

Let me first consider the concept of simultaneous experience using the classic example of the deer in a forest (Marton & Booth, 1997, p. 87). A person who was raised near a forest will not be afraid of a deer when he/she meets one on a walk. Another person who was raised in a city may feel very frightened when he/she meets a deer, since he/she is not used to meet such animals. These are two different ways of experiencing a deer on a walk. A third person who was raised in the city may act differently: he/she could start running away and yet shout that he/she is not afraid from the deer. This is clearly another way of experiencing the deer on a walk. The third person is *simultaneously aware of two aspects*: the fear from the deer and the fact that he/she does not want others to sense that he/she is afraid. Because this simultaneously awareness occurs in a single context, this is *another* way of experiencing the deer, and not one of the first two ways of experiencing.

3.1.5 First-order and second-order perspectives and descriptions

When statements are made about the world, this is a *first-order perspective*. The ways of experiencing the world through the eyes of the people experiencing it is called a *second-order perspective* (Marton & Booth, 1997, p. 118). The ways of experiencing the world, the situations, are usually taken for granted by those who experience them; they are not aware of them. The phenomenographic approach expects that the researcher will be aware of every aspect that is connected to the subject of the study, because it may affect the subject's behavior or his/her perceptions. Sometimes, in order to focus on a certain aspect among many others, we must put aside the others; this is called *bracketing* in phenomenography, although the researcher must remain aware of this fact. The researcher must consider all the results together at the end of the process.

3.1.6 What is the strength of phenomenography?

The phenomenographic approach deals with the variation of ways that people experience something. The researcher is interested in describing the phenomena in the eyes of the ones who experience it. This kind of research is usually done when there is no information about the way that people are dealing with the phenomena (Marton & Booth, 1997, p. 121). In the context of education, Marton (1993, as cited in Marton & Booth, 1997, p. 111) said that describing phenomena in the world as others see them is “the anatomy of awareness as seen from an educational point of view.” He was interested in the variation and the changes in the abilities of students while experiencing a phenomenon. The difference between those abilities can be categorized as less or more important for education. Phenomenography is a way to reveal, identify and formulate research questions that are relevant to a setting, for example, an educational setting (Marton & Booth, 1997, p. 111). Those questions should be of second-order perspective such as “What they actually thought learning was?” (Booth, 1992, p. 54) and “How did you arrive at the answer?” (Marton & Booth, 1997, p. 118).

3.1.7 Description and experience

The second-order categories of description, which are the results of the investigation, describe how the phenomenon is experienced. What sort of things are those descriptions and the experiences they describe? The descriptions should be like “some people think this, others think that, yet others think another way” without being judgmental (Booth, 1992, p. 54). The description of experience is the description of an internal relationship between the person and the phenomenon. Because we cannot describe the experience as a whole, we focus on the differences in the capabilities of the people that experience the phenomenon. We must be aware of the fact that we cannot deal with everything at the same time and in the same way; we can be aware of everything although not at the same time (Marton & Booth, 1997, p. 119), so bracketing must be used.

3.1.8 Individual and collective levels of description

The objective of a study is to reveal the variation, captured in qualitatively distinct categories of ways of experiencing the phenomenon in question, regardless of whether the differences are between individuals or within individuals (Marton & Booth, 1997, p. 124). This means that a description of a way of experiencing may be applied on individuals as well as across a group. One might speculate that each individual would have his/her own different perception of the phenomena, but experience has shown that this is not the situation; we can group individuals into a small number of categories of those conceptions (Booth, 1992, p. 56). The phenomenographer’s goal is to discover this small number of categories.

3.1.9 Categories of description

Marton and Booth (1997, p. 124) suggest that the way a person experiences a phenomenon constitutes one facet of the phenomenon as seen from the person’s point of view. The outcome space of those distinct ways (categories) of description is built from grouping some of the aspects together and from the relations among them. There are some criteria for building such categories: (1) Each category created should tell us something distinct about the relation between the person and the phenomenon; (2) The categories should have a logical hierarchical relationship with one another; (3) There should not be too many categories that are needed in order to capture the variation in the data. Each category has to have a name that is as precise as possible. Quotations or descriptions from the pool of the material should support the assignment of the name to a category.

Hierarchical order of categories

The result of phenomenographic research is an outcome space that consists of the categories describing the qualitatively different ways of experiencing a phenomenon. This outcome space should be hierarchically ordered:

> A particular way of experiencing something reflects a simultaneous awareness of particular aspects of the phenomenon. Another way of experiencing it reflects a simultaneous awareness of other aspects or more aspects or fewer aspects of the same phenomenon. More advanced ways of experiencing something are, according to this line of reasoning, more complex and more inclusive (or more specific) than less advanced ways of experiencing the same thing, "more inclusive" and "more specific" both implying more simultaneous aspect constituting constrains on how phenomenon is seen. (Marton & Booth, 1997, p. 107)

> The qualitatively different ways of experiencing a particular phenomenon, as a rule, form a hierarchy. The hierarchical structure can be defined in terms of increasing complexity, in which the different ways of experiencing the phenomenon in question can be defined as subsets of the component parts and relationships within more inclusive or complex ways of seeing the phenomenon. (Marton & Booth, 1997, p. 125)

Marton suggests two hierarchically orders: horizontal (linear) and inclusive:

> Depicting different ways of experiencing the same phenomenon (object of experience) can be logical related to each other - they depict parts of the same whole. The relationship may be one of horizontal or vertical differentiation. The latter is hierarchical - in terms of inclusiveness, complexity etc. (Marton, 1997)

According to the above citation, the ways of experiencing *can be* logically related to each other: can be, but need not to be. The relationship does not even need to be vertically differentiated where the categories are ordered in inclusive hierarchy; this is one possibility, but the relationship can also be horizontal. Therefore, it is not necessary to restrict the hierarchy to the vertical one of inclusiveness.

To summarize: a way of experiencing is an individual awareness; categories of description refer to the collective level; the categories can be hierarchically ordered vertically (inclusive hierarchy) or horizontally.

3.1.10 Methods of phenomenographic research

Collecting the data and analyzing it are not separated; rather they are intertwined. The researcher has to make several iterations while the research is being carried out (Marton & Booth, 1997, p. 129). The prime issues for phenomenographers are (Booth, 1992, p. 58): (1) Mapping the ways in which populations conceptualize, perceive and understand various aspects of the phenomena in the world they live in; (2) Categorizing those distinct ways; (3) Looking for a logical structure within the set of categories, and describing the relationship in the structure found as an outcome space; (4) Seeking empirical relationships between the categories and the principal focus of the study; (5) Applying the results to teaching and learning.

3.1.11 Collecting the data

In collecting the data the researcher wants to discover the ways in which subjects experience a phenomenon. The data being collected include interviews, field notes and the reflection of the person on his/her own experience called *meta-awareness* (Marton & Booth, 1997, p. 129), which means his/her being aware of his/her awareness of something.

Interviews are very important tool for revealing the subjects' perceptions of the phenomena of interest (Booth, 1992). In this style of research it is preferable to use a semi-structured interview, which is between the closed interview and the open one. The closed interview is centered on the interviewer who asks questions. The subject has to answer them and does not have room for expressing his/her thoughts. The open interview gives power to the subject who can express his/her thoughts to the interviewer, who in turn may ask questions to promote the conversation. The semi-structured interview is based on several pre-defined questions. Those questions deal with the research subject. The interview can take different paths from there and the interviewer should be prepared for such a scenario. Kroksmark

(1987, as cited in Booth, 1992, p. 60) claimed that there are two fundamental qualities that an interview must have in order to uncover the subjective thoughts. The first is the awareness by the subject of the interview's theme. The second is that the interview must be focused on the theme, and the interviewer must make corrections if there is a change in the path. This means that both sides know exactly what the theme of the interview is.

Every interview should have a part in which the subject is asked to reflect about his/her actions; this is difficult to perform, as it may cause resistance from the interviewee, but the researcher must repeatedly come back to it in alternative questions. This reflection is very important because it brings the subject to become aware of his/her own thoughts. In order to achieve this goal, phenomenographers form the interview according to the research question and ask the subjects specific questions that address this goal, for example: "What did the author mean"? And "How did you go about reading"?

3.1.12 Data analysis

The analysis is carried out simultaneously with the data collection until the researcher feels that she has the whole picture and structure, and has revealed most of the perspectives of the phenomenon. The researcher has to define boundaries on the data to be collected and analyzed so that it remains relevant to the research questions. We must remember that the researcher is a learner, seeking the meaning and structure of a phenomenon (how people experience it). The material collected is like a pool of information in which the researcher has to find the desired picture and structure of the phenomenon according to the subject's point of view (Booth, 1992, p. 62; Marton & Booth, 1997, p. 132). The researcher can do this by focusing on one of the aspects and seeking its variation while bracketing all other aspects. The material must be read in different ways: for each research question through all the interviews, as well as each interview as a whole (Booth, 1992, p. 62). When working with transcripts, the researcher should read them repeatedly, so that the researcher will become aware of every aspect, and ensure that none of them will be ignored while the bracketing is being done.

3.1.13 The reliability of the research

A question that is usually asked is: "If another researcher repeats the research, what is the probability that he will find the same results, the same categories and the same conclusions"? The reliability check that is suggested by Booth (1992, p. 67) is to ask a second researcher to study the material in light of the results. Afterwards, if the second researcher does not agree with the researcher's own categories, the latter must rephrase the categories by moving quotations from one category to another or changing their titles. If they still don't agree, the researcher may have to reanalyze the data.

3.1.14 The validity of the research

The validity of phenomenographic research is an important question. Is there a way to validate the results? The problem is that the researcher usually deals with a small number of subjects, and she wants the results to be accepted in the community. The validity of phenomenographic studies emerges from every aspect of the studies: from the design to the pool of data collected to the conclusions (Booth, 1992, p. 65). The claim is that the community can accept the results of phenomenographic studies because: (1) The researcher must have a deep understanding of the subject in focus, but he/she has to be open minded to new points of view of the subject. The expertise of the researcher promises that the results may help the community to improve its ways of experiencing the phenomenon because he/she has the ability to intertwine the old aspects and the new ones; (2) Although a small group of subjects is chosen, the researcher did so from a suitable population. The subjects were interviewed and observed and were asked to reflect their activities. The categories found in the outcome space should help the community choose an appropriate way to experience the phenomenon. This can be done only if the community is aware of that variation. Nevertheless, some other researcher may see other or more perspectives of the phenomenon.

3.1.15 Principles for teaching implied by phenomenographic research

Teaching can be improved as a result of phenomenographic research. Marton and Booth (1997) asked: "What methods of teaching can we devise to bring about the deep approaches[1] with their quality learning outcomes"? Their answer was "What we can say … is that the principle of achieving quality outcomes is to thematise both the act and the content of learning in the very act of teaching" (as cited in Booth, 1997, p.136). This led Booth (1997) to the following four practical principles:

1. The teacher should be aware of the content of learning and of the acts of learning (by the learner).
2. The teacher must take under consideration those educationally critical aspects related to the content of learning and the tasks perceived by the learner, so that they would not be taken for granted. Those critical aspects are aspects that without possessing a certain way of experiencing them the students will not be able to understand them (Marton & Booth, 1997, p. 65-67, 71-73, 79-81).

[1]Students have a deep approach to learning when they search for the meaning of the text and not just the meaning of the words.

3. The teacher has to ensure that the learners reveal their experience of learning, both the "what" and the "how." Teachers that are aware of the variations of ways of experiencing a phenomenon can use them to help students in the learning process.
4. The teacher must use tasks that are relevant to the learners' world, tasks that have personal meaning for the learner. In this way the students will be able to shift from not being able to do something to being able to do it (i.e. to learn).

3.1.16 Summary

"Phenomenography is a methodology as well as a theoretical framework that is being used for exploring and describing the cognitive relations which individuals and populations have with the world they live and move in" (Booth, 1992, p. 45). It provides an outcome space that consists of the qualitatively different ways in which people *understand* or *experience* a phenomenon (p.45). The description is from a *second order perspective*, which means the story as viewed in the eyes of the researcher.

Marton and Booth (1997) explain the term experience as: understanding, conceptualizing, and apprehending (p. 86). The authors developed a model for analyzing and describing the experience of learning (p. 85):

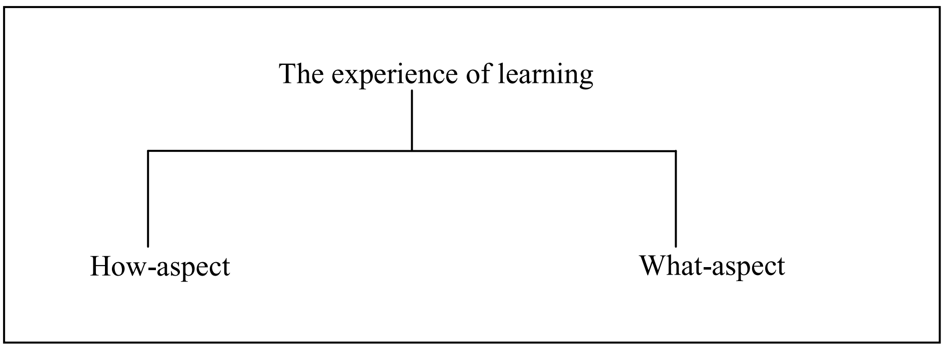

Figure-3 The model developed by Marton and Booth (1997, p.85)

The *what-aspect* relates to the content of what is being learnt and *how-aspect* refers to the learners' approach to his/her task.

I have adapted this model to the goals of my research. Instead of the experience of *learning*, I refer to the experience of *teaching using an animation system*. The *how-aspect* refers to how the tool is being used (the actions); the outcome space consists of the actions I have found that teachers do in the context of teaching with the animation system. This aspect includes abstract aspects, such as how teachers go about achieving their aims, which is similar to the approach used also by Berglund (2005, p. 42). The *what-aspect* refers to the teachers' experience of the tool; the outcome space consists of the ways of experiencing teaching with the animation system.

3.2 The Theory of Planned Behavior

3.2.1 The model

The *theory of planned behavior (TPB)* (Ajzen 1991; 2002a; 2002b) proposes a model about how human action is guided. The theory predicts the occurrence of a behavior that is *intentional*. The model suggests that there are three variables (attitudes, subjective norms and perceived behavior control) that predict the intention to perform a behavior. These variables also influence one another. The intentions are the precursors of the behavior. The names of the variables in the model have meanings in social psychology as discussed in the following subsections.

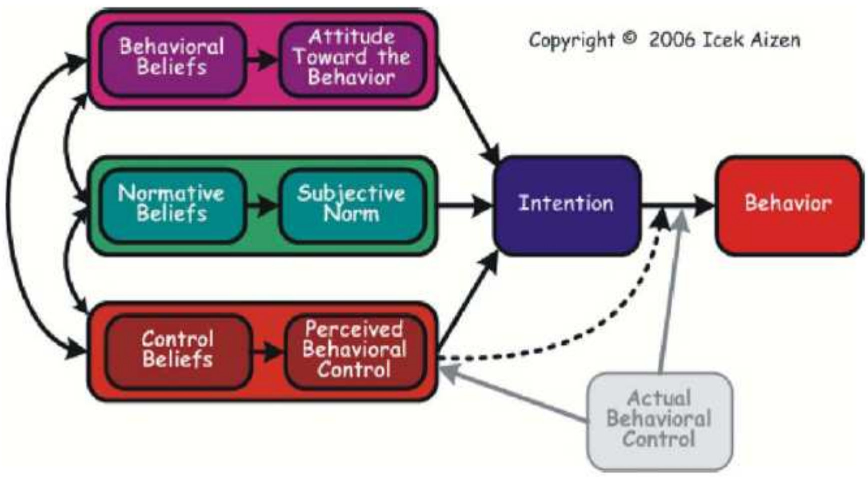

Figure-4 – Processes in TPB

(From http://www.people.umass.edu/aizen/tpb.diag.html)

3.2.1.1 Behavior

"*Behavior* is the manifest, observable response in a given situation with respect to a given target" (Ajzen, 2002b). In TPB, *behavior* is a function of compatible intentions and perceptions of behavioral control. Behavior is the observed human action that is a response to a given situation.

Behavior is defined by four elements (Ajzen & Fishbein, 1977, p. 889) whose acronym is *TACT*. **T**arget: the object that the behavior is directed or addressed to. **A**ction: the observed way the subject performs the behavior (Tobin & LaMaster, 1995, p. 226). **C**ontext: the context in which the action is performed, including all the surroundings that are related to the behavior but are not part of the behavior itself, for example, the particular classroom and the students (Kagan, 1992 as cited in Tobin, Tippins, & Hook, 1994, p. 246). **T**ime: when the behavior takes place. It is important that the precursors of the behavior (attitudes, subjective norms, perceived behavioral control and intentions) be defined with these elements, too.

The behavior that I investigated was: *the use of an animation system as a pedagogical tool.* Therefore, the *Target* is the animation system, the *Action* is its use, the *Context* is the way of using it as a pedagogical tool, and the *Time* aspect is either during a class or during a training course.

3.2.1.2 Intention

Intention is an indication of a person's readiness to perform a given behavior, and it is considered to be the immediate antecedent of behavior (Ajzen, 2002b). As I showed in the literature review, there is not a perfect relationship between behavioral intention and actual behavior. Inconsistency between the reaction to a new tool and using it in class can be found, for example, in Czerniak, Lumpe, Haney, & Beck (1999). Intention can be used as a proximal measure of behavior: "The stronger a person's intention, the more the person is expected to try and hence the greater the likelihood that the behavior will actually performed" (Ajzen & Madden, 1986, p.454). TPB does not predict behavior only according to intentions; it combines it with attitudes, perceived behavior control and subjective norms that will be explained shortly.

In my study, some of the intentions are: (a) "I will use the animation system in class" or "I intend to use the animation system in class" (a positive intention); (b) "I will not use the animation system in class" or "I do not intend to use the animation system in class" (negative intentions).

3.2.1.3 Attitude towards a behavior

Attitude towards a behavior is the degree to which the performance of the behavior is positively or negatively valued. This evaluation of the behavior by a person is assumed to have two components which work together: (1) beliefs about the consequences of the behavior (*behavioral beliefs*), and (2) the corresponding positive or negative judgments about each of these consequences (*outcome evaluations*).

For example: Behavioral belief – the use of an animation system in class decreases misunderstandings of concepts in CS.

Positive outcome evaluation – decreasing misunderstanding is desirable.

Behavioral belief – the use of an animation system in class will harm the role of the teacher in class.

Negative outcome evaluation – harming the role of the teacher in class is undesirable.

3.2.1.4 Subjective norms about the behavior

Subjective norms are a person's estimate of the social pressure to perform or not to perform the target behavior. The subjective norms contain two elements that are connected with each other: (1) the beliefs of other people that may be important to the person and how those other people like the person to behave (*normative beliefs*), and (2) the positive or negative evaluation of each belief (*motivation to comply*).

For example: Normative belief – I feel that I have to use the animation system since all my colleagues do.

Positive motivation to comply – In regard to what my colleagues think about the way I teach, doing what my colleagues say is important to me.

Normative belief – The developer says that using an animation system help students.

Negative motivation to comply – In regard with the developer's belief about an animation being helpful, this belief is not important to me.

3.2.1.5 Perceived behavioral control of the behavior (PBC)

Perceived behavioral control is the extent in which a person feels that he/she can control the behavior (Ajzen, 2002a). Perceived behavior control has two aspects: (1) how much *control* a person has on the behavior (*control beliefs*), and (2) how confident a person feels about his/her *ability* to behave in a certain way (*influence of control beliefs*). PBC is determined by control beliefs about the power of both situational and internal factors to inhibit or facilitate the performance of the behavior. Each of these aspects has a power on the belief that can be measured. In order to get information about the *strength of a control belief*, respondents are asked to indicate the perceived likelihood (or frequency) of a given control factor being present. In order to find the *power of the control belief*, respondents are asked about the how much (to what extent) the control factor's presence has the power to facilitate or inhibit the performance of the behavior.

For example: Negative control belief – I have low control of the installation of an animation system, because I am dependent on the technician.

Negative influence of control beliefs – if the technician is unavailable then I would not be able to deal with the installation by myself.

Power of the belief – installing the animation system all by myself is impossible.

Positive control belief – I am using an animation system that gives explanations. I can control the animation in order to give additional explanations. I can make the animation pause.

Positive influence of control beliefs – I am able to use the animation system as I need to in class.

Power of the belief – giving a better explanation in class is desirable.

3.2.1.6 Direct measures and indirect (belief-based) measures

The variables of the TPB model are psychological (internal) constructs except for behavior. Each predictor variable can be measured *directly* by asking participants about their attitudes, or *indirectly* by asking about specific behavioral beliefs and outcome evaluations. The differences between direct and indirect measures are based upon the self awareness of a person (Francis, Johnston et al., 2004, p. 46). There are people who can answer direct questions about their own beliefs, while others might find it difficult to answer the same question accurately. Therefore, instead of measuring an attitude *directly*, a person can be asked *indirectly* to inform about his/her capacity of behaving in a certain way and about the capacity's relative weighting. Using both direct and indirect measurements is important to get a better description of a person's beliefs.

To obtain the direct and indirect measurements I asked questions like the following examples:

Direct measurement: Using an animation system is good/bad.

Indirect measurement: By using an animation system I likely/unlikely help my students understand better. (The response is making a judgment about the probability that the given item is true)

The TPB questionnaire should consist of both *direct* and *indirect* measures of likelihood and outcome desirability (Ajzen, 1991). By weighting (multiplying) perceived likelihood (probability) by a number representing the outcome desirability, an estimate can be made of the size of the contribution of a specific belief to the global attitude (see the example in Section 4.3.1.4.2.3). This number is relative to the size of the contributions of other beliefs. Fishbein and Ajzen (1975) call the above process: "the *expectancy-value* model of the behavioral decision theory" (p. 31). Having both direct and indirect measures is important to capture the real predictors that a person has.

3.2.1.7 Summary

Ajzen (1991, p.181) said that "[t]he theory of planned behavior is a theory that was designed to predict and explain human behavior in specific contexts." A central factor in this theory is the individual's intention to perform a given behavior. Intentions are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try and of how much of an effort they are planning to make in order to perform the specific behavior. But intentions are not enough since the behavior depends also on other factors such as time, budget, cooperation with others, skills, etc. These factors represent "people's actual control over the behavior" (p. 182). TPB deals with perceived behavioral control that refers to people's perception of the ease or difficulty of performing the behavior of interest. TPB proposes that intention and perceived control over the behavior are the proximal predictors of behavior (p. 184-185). Ajzen and Fishbein (2000) and Ajzen (2002b) recommend using a 7 point Likert-type response format for the refinement of the response.

I am using the theory of planned behavior in order to construct a profile of each way of experiencing I found in the phenomenographic phase. The idea is to provide a tool for prediction of teachers who might experience the use of animation system in a negative way, and to approach them carefully. The profiles and the prediction using these profiles may also help expose the problems that innovators do not recognize concerning using software tools in class.

3.2.2 The reliability of the research

According to the TPB, direct measurements are to be examined for reliability by calculating the Cronbach coefficient alpha. Quoting Ajzen (2002b):

> The earlier description of direct measures emphasized the need to ensure high internal consistency in our measures of behavior and in the measures of intention, attitude, subjective norm, and perceived behavior control. This is the minimal requirement to confirm the assumption that the items selected do in fact assess the same underlying construct. Each item is, by itself, designed to be a direct measure of the theoretical construct, and the different items used to assess the same construct should correlate with each other and exhibit high internal consistency.

> For theoretical reasons, this requirement is not imposed on the belief composites that are assumed to determine attitudes, subjective norms, and perceptions of behavioral control. Accessible behavioral beliefs are assumed to account for attitude towards the behavior, accessible normative beliefs for subjective norms, and accessible control beliefs for perceived behavioral control. However, no assumption is made that salient beliefs are internally consistent. People's attitudes towards a behavior can be ambivalent if they believe that the behavior is likely to produce positive as well as negative outcomes. And the same is true of the set of accessible normative beliefs and the set of accessible control beliefs. Consequently, internal consistency is not a necessary feature of belief composites. (p. 8)

A similar citation can be found also in (Ajzen, & Driver, 1991, p. 193).

3.2.2.1 Correlations between the predictors

According to the theory of planned behavior, one should expect significant correlations between the direct measures and the indirect ones (Ajzen & Driver, 1991). A correlation is a single number that describes the degree of relationship between two variables (Research Methods Knowledge Base, 2007). Cohen (1988) has suggested the interpretations for correlations in psychological research shown in Table-1. (There are different interpretations for different disciplines.)

Correlation	Negative	Positive
Small	−0.29 to −0.10	0.10 to 0.29
Medium	−0.49 to −0.30	0.30 to 0.49
Large	−1.00 to −0.50	0.50 to 1.00

Table-1 – Interpretation for correlations in psychological research

The reliability check results can be found in Section 5.2.5.

3.2.2 The validity of the research

Validity of the scales for the indirect and direct measures of the TPB can be inferred from a variety of sources. First, *content validity* can be inferred for the indirect measures, since the salient beliefs emerged from the teachers' own responses to the questions that I asked them during the interviews of the phenomenographic phase and from the materials submitted by teachers of groups B and C. This means that the questionnaires were constructed on the basis of the phenomenographic interviews. Second, *construct validity* can be inferred from the significant correlations of the direct measures of the theory predictors with behavioral intention as indicated in the TPB.

3.3 The Integrated Methodological Framework

3.3.1 From phenomenography to TPB

The first phase of my study dealt with the ways CS teachers experience the use of an animation system as a pedagogical tool. I found that there are teachers who reject the system from the beginning, and therefore their voices do not appear in the study. The rejection is a behavior that should be studied in order to change it, and in order to understand the behavior, we should be able to predict it. Recall, also, the remark in Section 2.5 that the phenomenographic results are for populations, while teachers make their decisions according to their individual attitudes. This led me to the decision to use the theory of planned behavior as the theoretical framework in this phase.

This theory has been applied to the maintenance and change of health behaviors related to smoking, eating, etc. (e.g., reviews by Armitage & Conner, 2001; Godin & Kok, 1996, as cited in (Francis, Johnston, Eccles, Grimshaw, & Kaner, 2004)). More recently the TPB has been used to investigate the behavior of health care professionals (Francis, Johnston, et al., 2004). The theory helped to identify the specific beliefs associated with professionals' adherence to clinical guidelines. Therefore, I decided to adopt this theory in order to identify the behavior of CS teachers who I consider as professionals in both teaching and using software tools. The theory is used also to obtain the beliefs and attitudes that teachers possess.

3.3.1.1 Connecting TPB to CS teachers

According to the TPB, in order to predict whether a person *intends* to do something, I have to be aware of:

(1) Whether he/she agrees to do it (*attitudes*);

(2) How much he/she feels social pressure to do it (*subjective norm*);

(3) Whether he/she feels control of the action in question (*perceived behavioral control*).

More precisely, a CS teacher is used to a certain way of teaching. If a new tool is presented to him to use in class, will he/she choose to do so? The answer to this question depends on whether the teacher *intends* to do so, since the use of an animation system is not automatic, habitual or thoughtless. The intention depends upon:

(1) Whether the teacher has a positive or a negative attitude to the use an animation system in class;

(2) To what extent the teacher perceives that he/she experiences a social pressure to use or not to use the animation system from:

(a) The developers who encourage him to use it;

(b) Colleagues who use it or do not use it;

(c) The students' point of view, whether they like it or not.

It must also be considered how important these people are to the teacher;

(3) Whether the teacher finds it difficult to use the animation system, i.e., how difficult it is to enact the behavior in a given context.

With the TPB model, we can learn about how CS teachers' action is guided, i.e., what affects his/her behavior of using or rejecting an animation system as a pedagogical tool. The model predicts that specific behavior arises from intentions, which are predicted by three variables: attitudes towards the use of an animation system, subjective norms on how much social pressure is being used for using the system or not by the authorities, and perceived behavioral control of how confident and how much in control of the system the teachers feel.

3.3.2 A framework based on phenomenography and TPB

The analysis methodology I used is a combination of phenomenography and TPB. The next chapter describes the empirical investigation.

The diagram on the next page (Figure-5) describes my combined methodology. Rectangles represent actions and ellipses are the products of the actions. In the following description the number in parentheses describes actions in the framework labeled by the numbers.

The phenomenographic phase (1) produced categories (ways of experiencing an animation system as a pedagogical tool). Each category was found as a result of interviews, observations of CS teachers and written materials they submitted. The material collected in the phenomenographic phase formed the basis for building the TPB questionnaire (3), as recommended by Ajzen (2002b). I used the phenomenographic phase in order to elicit the information needed to build the questionnaire used for the TPB phase.

The research population consisted of four groups of CS teachers (marked as group A – group D). I have a personal acquaintance with the teachers from group A (2), since I met with them during a full school year frequently. I am also well acquainted with the teachers from group D, but less so than with the teachers from group A.

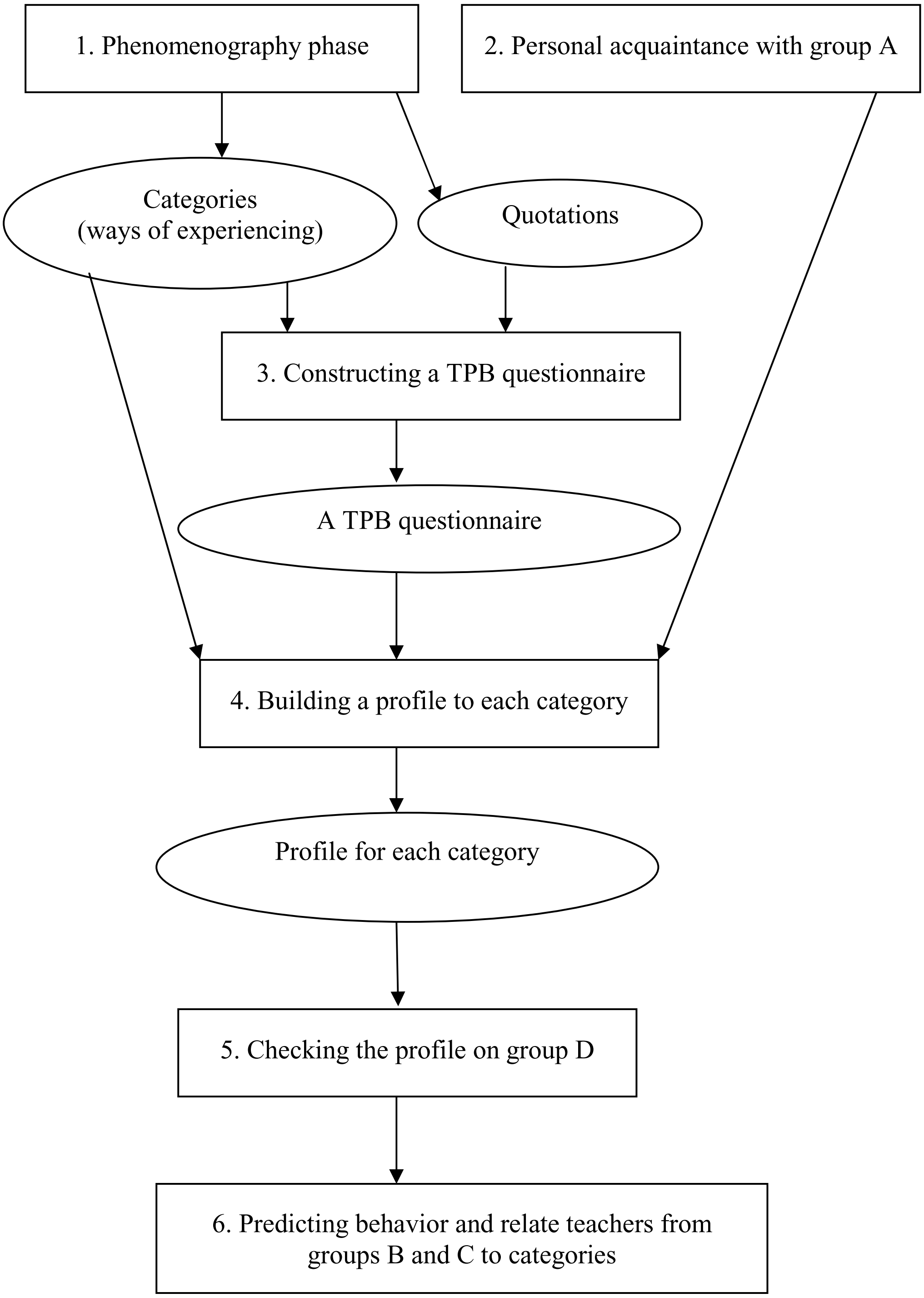

Figure-5 The integrated methodology

According to TPB, the size of the population should be at least 80 (Francis, Eccles, et. al, 2004, p. 28). Since only 25 teachers responded to my request to fill the questionnaire, I had to change (See chapter 5) the traditional TPB analysis although the flavor of the TPB was retained.

The analysis of the TPB questionnaires of group A was based both on TPB and phenomenography. This was how I related behavior found in the TPB analysis to the categories from phenomenography. The result of this analysis was a profile I constructed (4) for each of the categories found in the phenomenographic phase.

Then, I checked my profiles according to my personal acquaintance with group D and their phenomenographic interviews (5) in order to validate the results.

The last stage was to analyze the TPB questionnaires from groups B and C in order to predict their behavior (6) and to classify teachers into categories.

There are limitations to the prediction process, since I know that most teachers may experience a phenomenon as described in more than one category.

4. EMPIRICAL INVESTIGATION

4.1 Research Population

4.1.1 The population for the phenomenographic phase

Four groups of high-school teachers of computer science participated in the research:

Group A: Eight teachers who expressed a willingness to learn about Jeliot; they varied in their teaching experience and academic background. This investigation was carried out during the 2004 school year.

Group B: Forty teachers from a course on Java programming given to teachers from April to July 2005.

Group C: Fifty teachers from a course on Java programming given to teachers from August to October 2005.

Group D: Eight teachers from a 28-hour course on Jeliot given to teachers during the summer 2005.

The teachers from group A were asked to use Jeliot for a whole school year. The teachers from groups B and C took the course in Java because of a change in curriculum that required that they teach Java instead of Pascal. These teachers were exposed to Jeliot in the course and required to use it at least once in an exercise. The teachers from group D chose to take a course on Jeliot; four of them were familiar with Jeliot from the Java course, while the other four expressed an interest in using an animation as a pedagogical tool.

The teachers had a range of experience teaching computer science. From personal information collected during the interviews and from forms that they filled in during the courses, I found that most of the teachers had no experience in using an animation system. Several teachers in group D had become familiar with Jeliot when they were members of groups A, B, C.

4.1.2 The treatments given to each group

Group A: The teachers were introduced to the Jeliot animation system, and were then interviewed for about 30 minutes each. In addition, the teachers were observed as they used Jeliot in their classrooms. During the school year I made myself available for any questions that the teachers might have. At the end of the year the teachers were interviewed again for 30 minutes. The questions that guided the interviews can be found in Appendix A.

Group B: The teachers were introduced to the Jeliot animation system after studying basic concepts in Java programming. The teachers were asked to work with Jeliot, using it to solve problems in Java. Afterwards, the teachers were asked to prepare a lesson using the animation system and to describe their reasons for choosing this particular subject. The teachers also had to describe the problems they faced while preparing the lesson. Field notes were taken during observation of the lessons. When Jeliot was used again for studying the topic of trees, it was realized that they did not understand constructors in Java, and Jeliot was used to explain that concept. Following this explanation, the teachers were asked as a homework assignment to write their reactions towards the use of the animation system, as well as their opinions on how to use animation system in class, if at all.

Group C: The teachers were introduced to the Jeliot animation system after studying constructors in the Java course; this occurred at the very beginning of the course. They were taught how to use Jeliot in class, and were then asked to prepare a lesson using Jeliot. Field notes were taken during observations of the teachers' preparation of a lesson using Jeliot as a pedagogical tool. Their presentations were also observed as was the sharing of their reflections on their lessons. The teachers in this course were given the same homework assignment as the teachers in group B.

Group D: This course was offered to teachers who showed an interest in using an animation system in their classes. Unlike the teachers of groups B and C, one can infer that these teachers came with a positive attitude towards Jeliot, because they were willing to commit to a course on the subject after an initial exposure elsewhere (such as in the previous courses on Java). The course was designed as a result of what I had learned from the three groups described above. During the first phase of the 28-hour course; the teachers became familiar with all the features of Jeliot. In the second phase, the teachers were asked to use Jeliot to solve questions that had been given in matriculation exams; this was intended to make them feel comfortable with the system by using it in a familiar context. They were asked to prepare a lesson using Jeliot, to explain why they chose a specific subject, to describe the problems they faced, and to record how long it took to prepare the lesson. Observations were made as the teachers presented their lessons to the group and during reflections on their own work and that of their colleagues. Following the course, each participant was interviewed and they were asked to fill in a questionnaire on the use of animation as a pedagogical tool and to reflect on the course. The questionnaire can be found in Appendix B, and the notes of the observations can be found in Appendix C.

4.1.3 The population for the TPB phase

The population of the TPB phase consisted of 25 CS teachers who had responded the questionnaire that I sent them. The teachers in groups A and D were members of this population.

4.1.4 The teachers who became the "dissonant" group

I had three teachers who became familiar with Jeliot on various occasions. None of the teachers had participated a course, neither on how to use Jeliot nor on how to teach with it. Two of the three teachers were relative novices (2-3 years of teaching experience), but both of them were MSc students. The other teacher was a very experienced teacher with a BA in CS. These teachers used Jeliot in their classrooms, but each of them used it in only one manner that he or she became familiar with. All the three felt that they were "doing something improperly" and insisted on continuing to use Jeliot in spite of technical or pedagogical problems that they faced.

4.2 The Phenomenographic Phase

4.2.1 The data collection

As discussed in previous sections (Sections: 2.2.3.2, 3.1.2, 3.1.11) , interviews were the main tool for data collection in phenomenography, but a variety of sources of information was used in order to collect enough material to show the full variation in the ways of experiencing a phenomenon.

Four classes of material were collected:

1. All participants of groups A and D were asked to complete a personal questionnaire that asked about their previous experience with animation systems and their teaching experience. The personal questionnaire can be found in Appendix D.
2. The participants from group A were interviewed at the beginning and at the end of the school year, while the participants from group D were interviewed at the beginning and end of the course. The interviews were semi-structured as is usual in phenomenography. The design of the interviews was informed by three sources: (a) observations and notes from each teacher's classroom that I observed during the year; (b) my own experience in using an animation in class; (c) the literature review on teachers accepting or rejecting changes that is given in this report. The questions prepared in advanced for the interviews can be found in Appendix A. The points for observation can be found in Appendix C.

3. All participants handed in lessons and their reflections on the lessons that they had prepared.
4. All participants completed a questionnaire dealing with their experiences using the animation system as a pedagogical tool; they also included comments that they had on the use of animation by their colleagues in the course. The final questionnaire can be found in Appendix B.

4.2.2 Data analysis

The goal of the analysis is to reveal the ways of experiencing a phenomenon, here, the use of an animation system by teachers as a pedagogical tool. The analysis seeks variation in meanings which are associated to this phenomenon.

An iterative approach was required. The initial analysis involved becoming familiar with the transcripts of the interviews as a whole. [2] Each transcript was read and re-read numerous times in an attempt to reveal broad differences in pools of meaning in the data. The statements made by teachers were taken from their original context (decontextualised), and gathered again under a category (recontextualisation) that was common to all those statements, as described by Berglund (2005):

> This recontextualisation is made in an iterative process, where the researcher starts with a tentative understanding, and then through reconsiderations and refinement reaches a description that he or she finds relevant to address the research question and honest to the data. In a sense, the process can be seen as a discussion between the researcher, the pool of meaning and the developing categories of description.

In other words, when I as a researcher find categories of description, my goal is to describe the different ways of experiencing the use of an animation system as a pedagogical tool that I found among the teachers.

At this point, the transcripts of the individuals were once again read in their entirety. This process helped determine the context of some of the quotes and also revealed further relevant quotations that had not been extracted in the first round.

[2] The discussion is given in terms of interviews, but all the other resources were analyzed similarly.

The categories of description that were created resulted from my recontextualisation of the data. I discussed the ways categories were defined in Section 3.1.4. The results, as categories of description of certain phenomena, are to be interpreted at the collective level.

4.2.2.2 The data analysis process

The analysis of the materials from each group caused a re-analysis of the materials from previous groups. I will therefore present the analysis in chronological order.

The statements made by teachers from group A were decontextualised and then recontextualised. This analysis produced two categories for ways of experiencing Jeliot (see Section 5.1.1): *Appropriation* and *Repudiation*. In addition, I found *actions* that could be associated with each category, and these are also described in Section 5.1.3.

From the analysis of the data collected from group B, I discovered the category *By-the-book.* This time I used observation notes, lessons and reflections handed in by the teachers that participated in this group. I also found actions that could be associated with the new category. At this point I went *back* to the data I had from group A and recontextualised the quotations according to the three categories that I found. For example, the quotation: "I am using Jeliot only for demonstrations, exactly as I was taught in your course" was associated initially to the Appropriation category, but after discovering the By-the-book category it was shifted to that category. I became sensitive to the use of expressions like "exactly as I was taught in your course" that indicate that Jeliot was not appropriated.

The analysis of the data from group C revealed the category of *Dissonant*, as noted previously in Section 2.3.3 This category was the most difficult to establish. While analyzing the data from group C, I realized that some of teachers in group C who had also been subjects in group A expressed themselves ambiguously. On the one hand, they were positive toward the use of Jeliot and its benefits as a pedagogical tool (they expressed enthusiasm and used it in class when I came to visit), but, on the other hand, I observed that they came to class without any preparations at all for using Jeliot, and then attributed their own problems to Jeliot, claiming that it did not work correctly. (From conversations with students I learned that these teachers used Jeliot *only* during my visits.) I concluded that these individuals experienced Jeliot in a new way that I called Dissonant.

Again, as after the previous group, I went through all the pool of meaning once again and reassigned the quotations according to the new categories.

The data analysis of group D did not provide new categories, so I decided that no new subjects or contexts were needed in the phenomenographic investigation.

4.2.2.3 Summary of the analysis

The rationale for the research was to understand why the use of tools like animation is not widespread, despite their proven contribution to learning (as shown, for example, in my MSc thesis). Initially, I expected that investigating teachers who actually *use* Jeliot would provide the insights needed by developers and teacher-trainers to facilitate the acceptance of tools. I thought that the low acceptance was based upon the teachers' lack of awareness of the contributions of animation and the ways of using them, and on the fact that the systems might not fit the needs of the teachers. Upon encountering rejection, I was led to understand that the decision whether to use a software tool is often made just after being exposed to it; in this case, there is little value to investigating *how* animation is used. Instead, it would be more productive to study in depth teachers who rejected Jeliot.

4.3 The TPB Phase

4.3.1 Steps in the construction of a TPB study

4.3.1.1 *Definition* of the population

This was described above in Section 4.1.3

4.3.1.2 *TACT*

This was described above in Section 3.2.1.1.

The following sections (4.3.1.3–4.3.1.6) describe the construction of the questionnaire. The questionnaire consists of the questions as they appear in the boxes (below), although the ordering of the boxes was changed. The scoring for each section below refers to the analysis of the data. The division of questions in each section and the organization of the questions in each section were according to the recommendations of Ajzen (2002b) and Francis, Eccles et al. (2004).

4.3.1.3 Measuring *intentions*

I used the following three items to measure intentions:

1. I *expect* to use animation for explanations
   Strongly disagree 1 2 3 4 5 6 7 Strongly agree

2. I *want* to use animation for explanations
   Strongly disagree 1 2 3 4 5 6 7 Strongly agree

3. I *intend* to use animation for explanations
   Strongly disagree 1 2 3 4 5 6 7 Strongly agree

Scoring: By calculating the average of the three items—the higher the score, the stronger is the intention to perform the behavior.

4.3.1.4 Measuring *attitudes*

4.3.1.4.1 Direct measurement of *attitudes*

It is important that positive responses not all appear at one end of the scale (and similarly for negative responses) to minimize the risk of giving the same answer to all questions (Ajzen, 2002b):

A teacher takes a course on a certain programming language. The teacher has just been exposed to an animation system that can be used as a pedagogical tool.

Using of the animation system as a pedagogical tool is

Good (for students)	1	2	3	4	5	6	7	Bad (for students)
Pleasant (for me)	1	2	3	4	5	6	7	Unpleasant (for me)
Harmful (for students)	1	2	3	4	5	6	7	Beneficial (for students)
Useful (for me)	1	2	3	4	5	6	7	worthless (for me)

4.3.1.4.1.1 Scoring

- I changed the answers to items with negative endpoints so that the positive endpoint is the higher: 1 is changed to 7, 2 is changed to 6, etc.
- I obtained the attitude score by calculating the average of all the items.

4.3.1.4.2 Indirect measurement of *attitudes*: *behavioral beliefs* and *outcome evaluation*

In order to elicit the information needed to build the questions, I used the interviews with the teachers from groups A and D that I had already conducted in my phenomenographic study. The following box contains examples of questions asked in those interviews. This is an indirect measurement since it does not ask for the direct attitude as good or beneficial (as in the previous box).

> You have just studied about the Jeliot animation system; how to install it, how to work with it and how to use it in class.
>
> Please take a few minutes to list your thought about the following questions:
>
> What do you believe are the ***advantages*** of using Jeliot in class?
>
> What do you believe are the ***disadvantages*** of using Jeliot in class?
>
> Is there anything else you associate with using Jeliot in class as a pedagogical tool?

The answers that the teachers gave to these questions were used to construct the indirect questions in the following subsections 4.3.1.4.2.1 and 4.3.1.4.2.2.

4.3.1.4.2.1 Indirect measurement of the *behavioral beliefs*

Constructing questions to assess the consequences of the behavior found in the eliciting step was described at the beginning of section 4.3.1.4.2. I rephrased the advantages and disadvantages found there to obtain the following questions. The statements reflect beliefs which might affect the behavior (using animation in class by CS teachers). The following box consists of the questions for behavioral beliefs:

> a. If I am using an animation system in class, I feel that I am doing something positive for the students.
>
> Unlikely 1 2 3 4 5 6 7 Likely
>
> b. The use of animation system will cause my student confusion, since they are very weak students.
>
> Strongly disagree 1 2 3 4 5 6 7 Strongly agree
>
> c. If I use an animation system in class I may not have to deal with some understanding problems that I know that students face while studying concepts in CS.
>
> Strongly disagree 1 2 3 4 5 6 7 Strongly agree
>
> d. The animation system is not needed since I am an experienced teacher.
>
> Strongly disagree 1 2 3 4 5 6 7 Strongly agree
>
> e. If I use an animation system then I feel that I am not in control of my students' understanding.
>
> Unlikely 1 2 3 4 5 6 7 Likely
>
> f. The use of an animation system in class saves time.
>
> Strongly disagree 1 2 3 4 5 6 7 Strongly agree

4.3.1.4.2.2 Indirect measurement of the *outcome evaluation*

To construct questions to assess the strength of behavioral beliefs, I converted each one of the belief statements into the form of an incomplete sentence. By completing the sentence (using the given scale), the participant expresses a positive or negative evaluation of the belief statement.

g. Doing something positive for the students is:
   Extremely undesirable 1 2 3 4 5 6 7 Extremely desirable
h. Causing confusion for the students is:
   Extremely undesirable 1 2 3 4 5 6 7 Extremely desirable
i. Detecting understanding problems is:
   Extremely undesirable 1 2 3 4 5 6 7 Extremely desirable
j. Harming my role in class is:
   Extremely undesirable 1 2 3 4 5 6 7 Extremely desirable
k. Losing control on my students is:
   Extremely undesirable 1 2 3 4 5 6 7 Extremely desirable
l. Saving time is:
   Extremely undesirable 1 2 3 4 5 6 7 Extremely desirable

4.3.1.4.2.3 Scoring

For each behavioral belief, the belief score was multiplied by the relevant value of the strength of the belief. The sum of these products created an overall attitude score (for justification see Section 3.2.1.6). Using this method, the attitude score is computed by a*g + b*h + c*i + d*j + e*k + f*l, where the letters stand for the numerical values of the answers to the questions in the previous two boxes. A high score means that the participant is in favor of using an animation system as a pedagogical tool. A low score means that the participant is against using an animation system as a pedagogical tool.

A calculation of the range of attitude scores can give information on the place of the participant in the spectrum between in-favor-of and against using an animation system as a pedagogical tool. This range is calculated according to the number of items in the behavioral beliefs (6), multiplied by 7 (the 7 point Likert-type response format I used, see Section 3.2.1.7) and multiplied again by 7 for positive (the highest score in the Likert-type scale I used) or 1 for negative (the lowest score in the Likert-type scale I used). In this case, I have 6 items so the range is between 6*7*1 = 42 and 6*7*7 = 294.

4.3.1.5 Measuring *subjective norms*

4.3.1.5.1 Direct measurement of *subjective norms*

Direct measurements involve the use of questions referring to the opinions of people held to be important.

a. Most people who are important to me think that

I should 1 2 3 4 5 6 7 I should not

use an animation system in class.

b. The school management expects me to use an animation system in class.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

c. My colleagues use an animation system, therefore I feel social pressure to use an animation system in class.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

d. The instructor in the teacher training course who is important to me wants me to use an animation system in class.

Strongly disagree 1 2 3 4 5 6 7 Strongly agree

4.3.1.5.1.1 Scoring

1. I changed the items that have negative endpoints, so that higher scores reflect greater social pressure to use the animation system.
2. I calculated the mean of the item scores to get an overall subjective norm score.
3. The higher the score, the higher the social pressure the respondent experiences.

4.3.1.5.2 Indirect measurement of *subjective norms*: measuring ***normative beliefs*** and ***motivation to comply***

The population that is likely to apply social pressure with respect to the use of an animation system consists of: (1) the developers of the animation system, (2) the course instructor, (3) the school management, (4) the government, (5) colleagues, and (6) students.

- Are there any individuals or groups who would ***approve*** of your using an animation system as a pedagogical tool in class?
- Are there any individuals or groups who would ***disapprove*** of your using an animation system as a pedagogical tool in class?
- Is there anything else you associate with other people's views about using an animation system as a pedagogical tool in class?

The answers that the teachers gave to these questions were used to construct the indirect questions in the following subsections 4.3.1.5.2.1 and 4.3.1.5.2.2.

4.3.1.5.2.1 Indirect measurement of the *normative beliefs*

Questions were constructed according to what important people think a person should do (injunctive items a-b) and what important people actually do (descriptive item c).

a. Developers and the teacher training think that I

   Should not 1 2 3 4 5 6 7 Should

   use an animation system in class.

b. The school management would

   Disapprove 1 2 3 4 5 6 7 Should

   of my using an animation system in my class.

c. My colleagues

   Do not 1 2 3 4 5 6 7 Do

   use an animation system in class.

4.3.1.5.2.2 Indirect measurement of the *motivation to comply*

In order to measure this, I converted each one of the sources of social pressure into the form of a statement about the importance of the various sources of social pressure. By answering the questions, the participant indicated the strength of motivation to comply with each group.

d. The approval of my teaching by the developers and the training teacher is important to me.

   Not at all 1 2 3 4 5 6 7 Very much

e. What the school management thinks I should do is important to me.

   Not at all 1 2 3 4 5 6 7 Very much

f. Doing what other colleagues do is important to me.

   Not at all 1 2 3 4 5 6 7 Very much

4.3.1.5.2.3 Scoring

For each *normative belief*, the belief score is multiplied by the relevant value of the *motivation to comply* of the belief. The sum of these products creates an overall attitude score. Using this method, the normative belief score is: a*d + b*e + c*f.

A high score means that the participant experiences a social pressure *to use* an animation system as a pedagogical tool. A low score means that the participant experiences a social pressure *not to use* an animation system as a pedagogical tool. It might also be that the participant feels that he/she is expected to use the animation system but he/she does not care about these expectations.

A calculation of the range of attitude scores can give information on the place of the participant in the spectrum between experiencing social pressure to use an animation system as a pedagogical tool as opposed to not using it. This range is calculated according to the number of items in the normative beliefs (3), multiplied by 7 (the 7 point Likert-type response format I used, see Section 3.2.1.7) and multiplied again by 7 for positive or 1 for negative. In our case we have 3 items so the range is between: 3*7*1 = 21 and 3*7*7 = 147.

4.3.1.6 Measuring *perceived behavior control*

4.3.1.6.1 Direct measurement of *perceived behavior control*

I collected data that reflects subjects' confidence about their capability of performing the target behavior. This was achieved by assessing each subject's beliefs about:

(A) His/her beliefs about his/her *ability* to perform the behavior (the influence of control beliefs):

(1) How confident he/she is that he/she could do it (item 1)

(2) How difficult it is to perform the behavior (item 2)

(B) His/her beliefs about the *controllability* of the behavior:

(3) External - whether factors beyond his/her control determine his/her behavior (item 3)

(4) Internal - whether performing the behavior is up to him (item 4)

1. I am confident that I could use an animation system in class.

   Strongly disagree 1 2 3 4 5 6 7 Strongly agree

2. For me to use an animation system in class is

   easy 1 2 3 4 5 6 7 difficult

3. The decision to use an animation system in class is beyond my control.

   Strongly disagree 1 2 3 4 5 6 7 Strongly agree

4. Whether I use an animation system in class is entirely up to me.

   Strongly disagree 1 2 3 4 5 6 7 Strongly agree

4.3.1.6.1.1 Scoring

1. I changed the items that have negative endpoints, so the higher scores reflect greater level of control over the use of animation system.
2. I calculated the mean of the item scores to get an overall perceived behavior score.
3. The higher the score, the more the person feels in control and capable of performing the behavior.

4.3.1.6.2 Indirect measurement of *perceived behavioral control*: measuring *control beliefs* and their *perceived power to influence behavior* –

This section describes the instruments I used in order to elicit: (1) *control beliefs* that teachers posses in the context of using an animation system in class (control and ability); (2) *factors* that teachers believe would facilitate the use of an animation system or make it difficult to use (power of the control beliefs). The data sources were the interviews held with groups A and D in order to elicit commonly held beliefs, and the report of Naps et al. (2002). The first box shows the interview questions that I used in order to collect the data.

- What factors or circumstances would enable you to use an animation system as a pedagogical tool in class?
- What factors or circumstances would make it difficult for you to use an animation system as a pedagogical tool in class?
- Are there any other issues that come to mind when you think about using an animation system as a pedagogical tool in class?

The answers that the teachers gave to these questions were used to construct the indirect questions in the following subsections 4.3.1.6.2.1 and 4.3.1.6.2.2.

4.3.1.6.2.1 Indirect measurement of the *control beliefs*

The questions appear in the following box. I used the beliefs I found in the interviews and in the report, and divided them into external factors and internal ones. The controllability factors found were:

(A) External factors (not dependent on the teacher (items a-d)) such as: the laboratory equipment, the technician, the curriculum, the quality of the students, the school system.

(B) Internal factors (dependent on the teacher (items e-f)): the teacher's practice, knowledge and feelings of centrality (the explanations provided by the animation system might be perceived as a threat to the teacher; this might be perceived as implying that he/she does not give good explanations and cause him not to use the animation).

a. The laboratory in my school does not have the desired equipment to use this animation system (does not have a projector or does not have a software to show on all computers).

Unlikely 1 2 3 4 5 6 7 Likely

b. The technician in the laboratory is not competent.

Unlikely 1 2 3 4 5 6 7 Likely

c. My students are strong therefore so they are going to be bored.

Unlikely 1 2 3 4 5 6 7 Likely

d. The animation system is not a part of the curriculum.

Unlikely 1 2 3 4 5 6 7 Likely

e. The animation system provides explanations that are not needed.

Unlikely 1 2 3 4 5 6 7 Likely

f. The animation system requires that the teacher stand next to the computer.

Unlikely 1 2 3 4 5 6 7 Likely

Items a, b, e and f were used both as control factors and as factors that deal with the influence of control beliefs. For example, item b describes both the fact that a teacher might feel that he/she is incapable of dealing with problems in the laboratory, and this might lead also to the feeling that he/she cannot control the class. The controllability internal factors are ability factors since they have an effect on the teachers' ability to use the animation system.

4.3.1.6.2.2 Indirect measurement of the *power of the factors* that influence the behavior

I converted each one of the control belief statements into the form of an incomplete statements about whether this makes it more or less likely to behave in a certain way, or whether it makes the behavior easier or more difficult to perform. This is done in order to capture the strength of the belief (how strong or weak it is).

g. Having problems with the laboratory, makes it

much more difficult 1 2 3 4 5 6 7 much easier

to use an animation system.

h. Incompetent technician makes it

much more difficult 1 2 3 4 5 6 7 much easier

to install the animation system.

i. When students feel bored while using an animation system, I am

less likely 1 2 3 4 5 6 7 more likely

to use it.

j. Teaching with something that is not in the curriculum, makes me

less likely 1 2 3 4 5 6 7 more likely

to use it.

k. The explanations provided by the animation system causes me

less likely 1 2 3 4 5 6 7 more likely

to use it.

l. The animation system requires my standing next to the computer and not wander among my students, makes it

much easier 1 2 3 4 5 6 7 much more difficult

to use.

4.3.1.6.2.3 Scoring

For each control belief, the belief score is multiplied by the relevant value of the strength of the control belief. The sum of these products creates an overall perceived behavioral score. Using this method, the attitude score is: a*g + b*h +c*i + d*j + e*k + f*l. A high score means that the participant feels in control of using an animation system as a pedagogical tool. A low score means that the participant does not feel in control of using an animation system as a pedagogical tool.

A calculation of the range of attitude scores can give information on the place of the participant in the spectrum between feeling in control and not feeling in control of using an animation as a pedagogical tool. This range is calculated according to the number of items in the behavioral beliefs (6), multiplied by 7 and multiplied again by 7 for positive or 1 for negative. In our case we have 6 items therefore; the range is between 6*7*1 = 42 and 6*7*7 = 294.

4.3.1.7 *Constructing the whole questionnaire*

The above sub sections (4.3.1.3–4.3.1.6) describe the questions. The questions were categorized according to the specific items that I wanted to measure. These questions were put into boxes. The questionnaire was constructed by joining all the questions that appear in the above boxes into one long questionnaire. I deliberately changed the order of the boxes, but kept the order within the boxes. As recommended by Ajzen (2002b) and by Francis and Eccles, et. al (2004, p. 26 at the bottom), this was done to minimize the option of the participants giving the same answer unless they really meant to.

This questionnaire was translated into Hebrew and was sent to all the teachers in the study population (groups A-D). The questionnaire can be found in Appendix E.

4.3.2 Data analysis

Each of the questionnaires was sent to the teachers and analyzed as follows:

The first step was building a scoring table for the questionnaire answers. The scoring table can be found in Appendix F. The table contains the connection between the question number and the variable it measures. It indicates which questions should be recoded because of negative end-points and which rows should be multiplied in order to calculate the total score of indirect measurements.

The second step was entering the data into an Excel file. The questionnaire items were listed in the same order they appear in the questionnaire. I labeled each row according to the variable it represents and colored it to make it easy to visualize.

The third step was the analysis of the direct measures of the predictor variables. I recoded the negative end-points items; then, I calculated each of the mean measurements scores as I described in Subsections 4.3.1.3 to 4.3.1.6 above.

The forth step was the analysis of the indirect measures. I multiplied the beliefs with their strength for each of the respondents (Subsections 4.3.1.3 to 4.3.1.6). Finally, I added the results of the multiplications for each variable for each respondent. This created the scores that are required.

The fifth step was different from the original TPB methodology. I looked at each of the respondents' scores and categorized the respondents according to the scores they got. Then, I tried to relate this categorization to the data I had from the phenomenographic phase of my study.

5. RESULTS

5.1 The Phenomenographic Phase

The questionnaire that was used to collect the teachers' personal details (See Appendix D) showed that most of them were not familiar with animation systems. Their CS teaching experience varied from not experienced to teachers who had more than 15 years of teaching. Most of teachers had a BA degree, but not all of them were in CS. Most of the teachers did not know Java, the computer programming language that Jeliot animates.

5.1.1 The outcome space

The result of a phenomenographic study is a hierarchically ordered set of categories that are the ways of experiencing the phenomenon under observation. I found four ways of experiencing the animation system as a pedagogical tool and three categories of actions. The ways of experiencing are related to the what-aspect and the actions relate to the how-aspect in the model developed by Marton and Booth (1997) (see Section 3.1.17). The following tables Table-2 and Table-3 summarize the two outcome spaces I found:

Category	**Way of experiencing (the what aspect)**
Appropriation	Jeliot is experienced as a useful tool consistent with the teacher's pedagogical style.
By-the-book	Jeliot is experienced as a possibly useful tool, but it may not fit with the teacher's pedagogical style.
Repudiation	Jeliot is experienced as an externally imposed tool of limited usefulness for teaching.
Dissonant	Jeliot is experienced in a conflicting manner: on the one hand with enthusiasm and on the other with a reluctance to actually use it.

Table-2 The outcome space of the what-aspect

Category	**Actions (the how aspect)**
Integrated into practice	Frequent use of the animation; use of novel methods; use for inquiry; integration of the animation system into classroom activities.
Algorithmic practice	Use the animation as an algorithm, following the exact instructions given in the course; use the animation system on special occasions such as teaching a new subject.
Rejection	Do not use the system at all; confident that the animation system is not a useful pedagogical tool.

Table-3 The outcome space of the how-aspect

In the following subsections I expand the description of each category that I found for each of the outcome spaces. The quotations from interviews are the justifications for the categories.

5.1.2 Ways of experiencing the use of Jeliot as a pedagogical tool

5.1.2.1 Appropriation

Jeliot is experienced as a useful tool consistent with the teacher's pedagogical style. When experiencing Jeliot as a pedagogical tool in this way, teachers say that they use it *routinely* in their classes. Jeliot is integrated within their lessons even in novel ways that the teachers were not exposed to in the course. They use gestures and ways of explaining material in class that are based upon the displays and functioning of Jeliot, even when the system is not used.

Quotations associated with the category

"I used [Jeliot] for explanations, demonstrations and explorations in class."

"I am using all modes of the animation system as needed in class."

"I know that my students will not grasp the idea unless I use the Step option."

"I am using the smooth display of Play only after I feel that my students understood me and after I opened their minds towards the specific item".

"I am using Run-Until when I want Jeliot to do something not relevant to the current lesson. At that time I explain the whole meaning of what I intend to show."

"I am using Jeliot as a tool that can explain all the previous information needed. I created a library that contains all the necessary information to the subject that is being discussed in class."

It is clear that the above teachers appropriated Jeliot to the extent of using Jeliot as an inquiry tool, although such use was not taught in the course. These teachers felt confident using the animation system; they were able to use it freely and to adapt it to their needs.

Two teachers were observed using gestures that were taken from the animation to explain the data flow; that is, they used their hands to describe how data is moved from one cell to another in the same manner as it is portrayed in Jeliot. The use of gestures from Jeliot — out of the context of the software — is a further powerful indication of appropriation.

5.1.2.2 By-the-book

Jeliot is experienced as a possibly useful pedagogical tool, but one that may not fit with the teacher's pedagogical style. When experiencing the use of animation as a pedagogical tool in this way, teachers say that they used the animation system from time to time, but that they were not yet sure about the benefits of its use. They express uncertainty about how to use the system, and even when they do use it, they use only one canonical mode that they learned in the course ("by the book"). These teachers do not use the animation system routinely, but only when new concepts are studied; this is explained by the desire not to waste time. The teachers have to know exactly what to do, so they feel that they have to prepare themselves properly; therefore, they express uncertainty.

Quotations associated with the category

"I use Jeliot only when I teach a new subject or when I feel the need to attract my students."

"I am using Jeliot only for demonstrations, exactly as I was taught in your course."

"I am not sure that Jeliot will be so helpful to my students since there are both good and bad students. But I am willing to try."

"I will have to work a lot before coming to class, can you help me?"

These teachers were not yet convinced of the effectiveness of Jeliot. They were very careful in its use, since they felt that they were just novices themselves. They looked upon animation primarily as a way to increase motivation. They felt that they would have to work hard but they were willing to try. These teachers did not use Jeliot as frequently as those in the Appropriation way of experiencing. All the teachers asked for help from the instructor of the Jeliot course.

5.1.2.3 Repudiation

Jeliot is experienced as an externally imposed tool of limited usefulness for teaching. They chose not to use an animation system at all immediately after being exposed to Jeliot for the first time, and they *provided reasons* for this rejection, but the reasons usually did not refer to themselves, but to the environment: the technician, the students, and the curriculum. These teachers say that they do not find any advantage in using Jeliot since it is pedagogically useless. They feel that Jeliot might harm their central role in class.

Quotations associated with the category

"Jeliot shows aspects [of the execution of a program] that no one needs animation to understand because they are easy to understand."

"I do not see why I have to use Jeliot, my students always understand me."

"I have very strong students who do not need animations."

"I would have to become dependent upon the [computer lab] technician." "I am a very experienced teacher and I do not need any help."

"Jeliot is not a part of the curriculum."

The above teachers exhibited rejection *immediately* after seeing Jeliot for the first time. They felt that Jeliot might harm their centrality in class. The teachers found many reasons for not using Jeliot, but the reasons usually did not refer to themselves but to the environment: the technician, the students, and the curriculum. These teachers did not use Jeliot at all.

5.1.2.4 Dissonant

Jeliot is experienced in a conflicting manner, on the one hand with enthusiasm and on the other with a reluctance to actually use it. These teachers were the most difficult to analyze since I was not sure what their real attitudes were. When they were exposed to Jeliot they showed enthusiasm, but they were skeptical about its benefits. They came to class unprepared and therefore they thought that Jeliot was not useful. On the other hand, they were afraid that if they did not use the animation system they would be left behind by their colleagues who did use it.

Quotations associated with the category

The following three quotations were given by the *same teacher* within an interview, and demonstrate that Jeliot can be simultaneously experienced (as described in section 3.1.4) in both positive and negative terms:

"Jeliot is a beautiful environment." (positive)

"I will have to use Jeliot since I do not want to be different from other teachers who use it." (negative)

"I am using Jeliot only for explanations." (positive)

The following teacher expressed enthusiasm for using Jeliot, but this was not consistent with the way she actually used it: only when I came to observe a lesson, and without planning its use in advance; this caused her to make many mistakes.

"Jeliot is a very helpful environment" (positive)

"The system is not good to use in class …. It has many bugs in it …. I do not have the time to use it in class." (negative)

The following teacher expressed positive attitudes towards the use of Jeliot in class but simultaneously felt that she is doing something "wrong":

"I like to use Jeliot in a class, I am using it as a working environment, my students do not know any other environment" (positive)

"I do not know how to use the options that are provided by Jeliot, the options that I see in Jeliot" (something "wrong")

The something "wrong" is a negative feeling that the teacher expressed in the interview. She was aware of the fact that Jeliot has more options but she uses only compilation and run as she would do with any working environment. She did not use the animation options at all. This teacher belongs to the other group of dissonant teachers that I referred to in section 4.1.4.

5.1.3 Actions

The categories of the actions were based primarily on observations, although occasionally teachers referred to actions in the interviews. The results show that there is a connection between the ways of experiencing and the actions. As a matter of fact, the actions helped me to discover each way of experiencing. But, the actions do not necessarily have to correspond one-to-one with the ways of experiencing, and, in fact, I found only three actions. One may argue that a teacher can experience Jeliot in an Appropriation way but act in an Algorithmic way, but I did not encounter such a situation.

A dissonant teacher usually rejects the use of the system, but I later found that there were two groups of dissonant teachers, and that the teachers in one of them did in fact use the system. This is explained in detail below.

5.1.3.1 Integrated into practice

The teachers who act in this manner use Jeliot frequently in their classrooms; it looks natural and is an integral part of their practice. They use the animation system in novel ways that they invented by themselves according to their own needs in the class. These teachers used most of the features of Jeliot and could explain why they prefer to use some features and not to use others. These teachers explicitly say that they teach and explain as if Jeliot was currently available in the classroom even when it was not. The teachers in my study who acted in this manner experienced Jeliot in the Appropriation way.

5.1.3.2 Algorithmic practice

The teachers who act in this manner use Jeliot from time to time in their classrooms, especially when they teach a new concept. These teachers prepare themselves a lot before class, they ask a lot of questions in order to be sure that they are correct and they act as they were taught to do in the training course. The teachers who acted in this manner experienced Jeliot in the By-the-book way.

5.1.3.3 Rejection

The teachers who act in this manner do not use Jeliot at all. The teachers who acted in this manner experienced Jeliot in the repudiation way.

5.1.4 The hierarchy of the categories

According to phenomenography the outcome space should be hierarchically ordered (Subsection 3.1.9). The hierarchy of the outcome space of my study can be defined in an inclusive (vertical) way, but also in a horizontal (linear) one. I also developed another hierarchy that is integration between the inclusive and horizontal hierarchies. All the hierarchies present the same order within the outcome space; the difference is the description of the criteria for the order. In the following subsection, I present the three hierarchies.

5.1.4.1 Inclusive hierarchy

The criterion for ordering the categories in an inclusive hierarchy is: in the description of the categories each level includes the previous one.

I place the Dissonant category at the lowest level of experiencing Jeliot as a pedagogical tool. While experiencing Jeliot in such a manner, the teachers in fact reject the system, but they do not say it *explicitly*. I call this kind of rejection a "bad" rejection since it is not based on pedagogical reasoning, but on fear or lack of confidence. This is the worst case, since this way of experiencing describes teachers who do not feel good with what they are doing and they might unintentionally harm their students.

The Repudiation category includes the Dissonant characterization, since in this category the way of experiencing is to reject the system. The Repudiation category adds the characteristic of justifying the rejection on solid pedagogical grounds that the teacher possesses. The difference is that the teachers that experience Jeliot in this manner explicitly say that they reject the system and are not ashamed to say so. These teachers feel good about their decision. The teachers that belong to the Repudiation category give pedagogical reasons for not using Jeliot. This is a kind of rejection but with the addition of pedagogical reasons.

If we consider Repudiation and Dissonant as rejection we could say that the rejection is included in every way of experiencing, as it is like the mathematical convention of saying that the empty set is included in every set. I think that this seems unnatural; it does not make any contribution to understanding the categories. To do so, I would be manipulating the categories in order to fit them within an inclusive hierarchy. But I will continue in this approach just to complete the hierarchy.

The By-the-book category describes the way of experiencing the system in an algorithmic way. It of course includes Repudiation in the way that an empty set is included in every other set. Another explanation is that a rejection (whether with pedagogical reasoning or without it) is natural step towards changes. This is the place where I found that the inclusive hierarchy does not fit my categories. I felt that the explanations are either imposed or unnatural.

The Appropriation category describes the highest category in the hierarchy since it characterizes the way of experiencing on its highest levels of using the system; for example, use for inquiry, use as needed in class, etc. The By-the-book category is included because teachers in the Appropriation category will also use the system in an algorithmic way.

The following Figure-6 describes the hierarchy. The diagram represents each of the categories when the quoted phrases are the addition for the category.

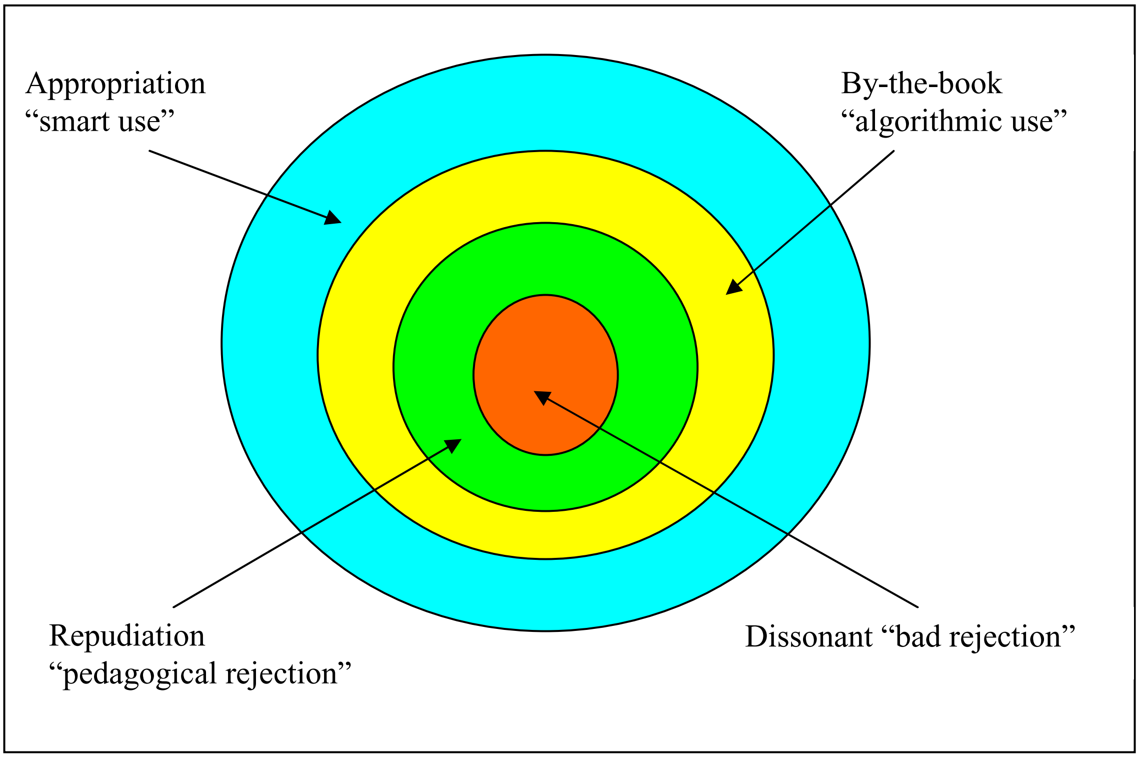

Figure-6 The inclusive hierarchy of the what-aspect

5.1.4.2 Linear hierarchy

The criterion for ordering the categories in a linear hierarchy is the level of the teacher's interaction with the animation system as a pedagogical tool. The decision as to which level is "higher" or "lower" is based on my experience both as a teacher who used Jeliot in class for more than 10 years and as a researcher who studied Jeliot and the effect of using it with students. According to phenomenography, the researcher should be very experienced in the area he/she studies so that she can make decisions, for example, on the hierarchy.

In the Dissonant category, the teacher does not use Jeliot at all or uses it only under compulsion. He/she usually uses the system only to please authorities without obtaining any pedagogical benefit. In the worst cases I saw that teachers improvise, come to class unprepared and use Jeliot incorrectly. Therefore, I place the Dissonant category as the lowest, because it has the potential to cause harm to the students' learning.

The Repudiation category is a better way of experiencing because the teachers who experience Jeliot this way are aware of the reasons for the rejection. This way of experiencing involves knowing the system in order to reject it. Therefore, they cannot harm the students, as they have alternate pedagogical methods that they believe are effective.

The By-the-book category describes a better use of the system, although the use is only in an algorithmic way. The students will derive benefits from using Jeliot in those contexts and in the manner that the teacher uses it, although these may be limited by the algorithmic way of use.

The Appropriation category is the highest one since it describes a way of experiencing Jeliot to its maximal potential as a pedagogical tool. Jeliot is used when needed in class, and the options provided by Jeliot are chosen according to the class activities. Jeliot is used in novel ways invented by the teacher as the need arises. This is clearly the highest level of using the system. Teachers that belong to this category appropriated Jeliot to their teaching style.

In the linear hierarchy, I cannot say that a teacher "belongs" to more than one category, but I can say that this hierarchy defines a spectrum of categories with the above four categories bands of the spectrum. In fact, I found teachers who can be placed at the border between these categories; this happens when a teacher is able to shift from one category to another.

Furthermore, one teacher can belong to more than one category when the context is changed. The context depends on the class, the topic being taught, the school, etc.; for example, the same teacher can say that he/she uses Jeliot very often and with many options when he/she teaches an advanced topic by recursion (Appropriation or By-the-book), but he/she does not use it at all to teach arrays because he/she believes that the visualization that Jeliot provides for arrays is inadequate (Repudiation).

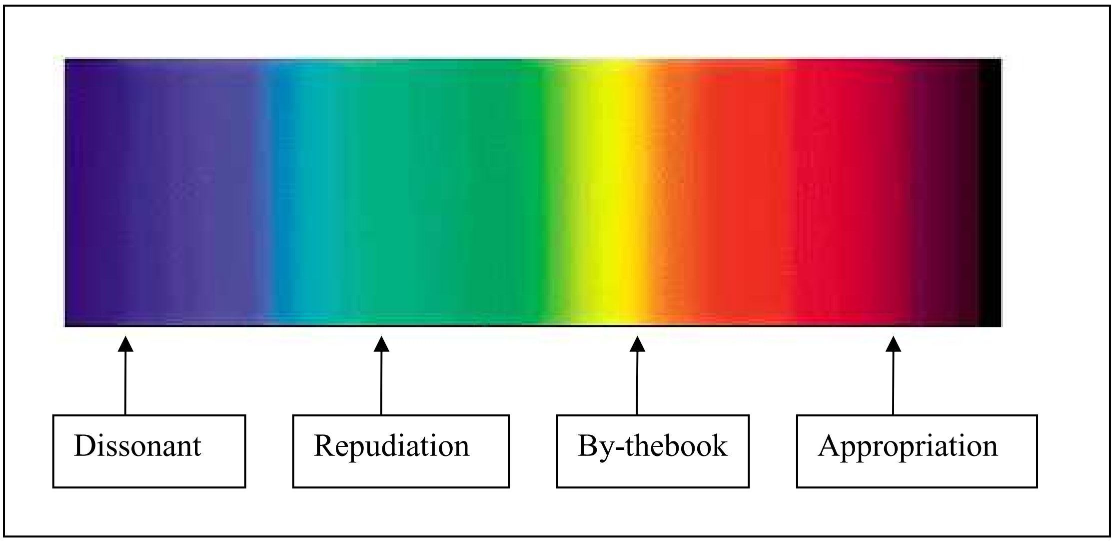

Figure-7 The spectrum of the categories

5.1.4.3 Linear-Inclusive hierarchy

The outcome space I got for the what-aspect can be hierarchically ordered according to the focus of *how a teacher perceives his/her role in a class*. The more the teacher feels confident of his/her central position in class and the more he/she is comfortable with his/her level of expertise, the easier it is for him to bring the use of the animation system into his/her practice. The order of the categories in the outcome space is based upon the extent to which a teacher considers himself to be an authority and/or a facilitator. An *Authority* is a teacher who says that he/she is the leader of the teaching process in class; he/she perceives his/her place as the center of the teaching process. A *Facilitator* is a teacher who says that his/her role is to guide the students; he/she puts the student in the center of the teaching process. The hierarchy is described in an ascending order.

The *Dissonant* teacher knows that he/she would not like to use the animation system in class because he/she feels that it would threaten his/her centrality in class; however, he/she cannot say so explicitly. The Dissonant teacher perceives his/her role in class as that of an *Authority* and not as a *Facilitator*, but he/she cannot and will not admit it.

The *Repudiation* teacher would say that he/she is the one who should be at the center of teaching, since he/she is the one who knows best; this will give his/her students confidence in him. Therefore, although he/she can and is able to use the system, he/she will not use it in class. A Repudiation teacher perceives his/her role in class as an *Authority* and not as a *Facilitator*, and he/she explicitly states that this is his/her role.

The *By-the-book* teacher feels that he/she is not confident with the use of the animation system. Therefore, he/she has to ask a lot of questions about how he/she should introduce the system into his/her practice. Therefore, the By-the-book teacher does not perceive himself fully as an *Authority*. This teacher is willing to use the animation system in class in order to help his/her students. But, because of the lack of confidence with using the system, he/she does not perceive himself fully as a *Facilitator*. Therefore, he/she perceives his/her role in class as somewhere *between* an *Authority* and a *Facilitator*.

The *Appropriation* teacher feels confident with the use of the animation system, he/she says that he/she can use any kind of option that the animation system provides according to the situation in class and according to his/her needs as a teacher. This teacher does not feel threatened by the animation system. He/she feels that on one hand he/she is the leader of the teaching process in class—*Authority*—and at the same time he/she puts the student in the center of the teaching process— *Facilitator*. Therefore, he/she perceives his/her role in class *both as an Authority and as a Facilitator*

The Appropriation category possesses both roles: facilitator and authority. The By-the-book category is between the Appropriation and Repudiation since it possesses the two roles too, but the uncertainty of the use of animation system puts the category in between. The Repudiation category possesses only the authority role and so does the Dissonant category. The difference lies in the ability of the Repudiation teacher to admit this fact explicitly, so I have placed it higher in the hierarchy.

This hierarchy is less than ideal since we have here a combination of more than one aspect. The categories depend upon both the centrality issue and the degree of the use of the animation system; these two aspects are intertwined and therefore affect each other. This connection can be explained as the connection between the beliefs (centrality) and the behavior (the degree of the use of Jeliot).

5.2 The TPB Phase

5.2.1 TPB scores for each teacher

This subsection contains the results of the third and the fourth steps (Section 4.3.2).

Table-4[3] is one of the results of step 4 of my integrated methodology (Figure-5); therefore, it gives the scores of only six teachers from group A out of my analysis for the 25 teachers. I chose only group A at this stage of the research since this is the group of teachers that I was most familiar with and that I was in touch with for a school year. The Predictor column holds the names of the TPB predictors, the Range column describes the minimum and maximum *measured scores* for each predictor as described in Section 4.3.1 (scoring), the next six columns hold the scores for the teachers in group A. The number in each cell represents the score that that teacher (T1-T6) got for the predictor. For example, the highlighted cell holds the value that teacher T3 got for the predictor: "direct perceived behavior control."

(n=25)

Predictor	Range	T1	T2	T3	T4	T5	T6
indirect attitude	6 – 294	242	217	237	245	237	163
Direct subjective norms	1 – 7	4.6	2.3	5	3.7	4.6	3.3
indirect normative belief	3 – 147	17	50	147	57	60	66
direct perceived behavior control	1 - 7	6.6	4.3	7	7	6.3	6
indirect perceived behavior control	5 - 245	99	89	73	170	49	108
Direct behavioral intentions	1 -7	6	4.3	7	5.6	7	6

Table-4 – The TPB scoring of group A

5.2.2 The quartiles

As I wrote in the methodological framework (Subsection 3.2.1.7), I want to be able to categorize the teachers; therefore, I decided to categorize the teachers according to their scores, as they appear in the above table. Since the population is small, I decided to divide the scores into quartiles. The quartiles were calculated by dividing the range of the TPB expected low and high scores into four sub-ranges.

[3] During the analysis process I faced a problem: it seemed that question 30 and its related belief were problematic, since a teacher can say that he likes to wander among his students and at the same time say that he believes that an animation might require that he stand near the computer; therefore, this does not say anything about the teachers' control beliefs. After examining this again I decided that I should omit the question. Omitting question 30 and its related belief question 12, affected only the results of the indirect measurement of the perceived behavior control (row 5 in Table-4).

Range according to TPB

Indirect Attitudes

quartile	low	high
1st	225	294
2nd	154	224
3rd	80	153
4th	6	79

Indirect normative beliefs

quartile	low	high
1st	116	147
2nd	79	115
3rd	42	78
4th	3	41

Indirect perceived behavior control

quartile	low	high
1st	185	245
2nd	125	184
3rd	65	124
4th	5	65

Direct measures – subjective norms, perceived control, intention

quartile	low	high
1st	5.51	7
2nd	4.1	5.5
3rd	2.51	4
4th	1	2.5

5.2.3 Scoring each of the members of group A

For each of the predictors I built a table with the score of each of the teachers according to these quartiles. Table-5 is the same as Table-4 in Subsection 5.2.1, except that it has quartiles in it instead of numbers.

(n=6)

Teacher	Indirect attitudes	Direct subjective norms	Indirect normative beliefs	Direct perceived behavior control	Indirect perceived behavior control	Direct intentions	Categories found from phenomenography
T1	1	2	4	1	3	1	Appropriation
T2	2	4	3	2	3	2	By-the-book
T3	1	2	1	1	3	1	Dissonant
T4	1	3	3	1	2	1	Appropriation
T5	1	2	3	1	4	1	Dissonant
T6	2	3	3	1	3	1	Shifted from Repudiation

Table-5 – The scoring of group A

The last column shows the categories that I found for each teacher in the phenomenographic phase. This helped me build the profiles. The description of each category can be found in Section 5.1.

One of the results that can be observed here is that the indirect perceived behavior control has the score 3 for most of the group's members, while the direct score of the same predictor is mostly 1. This is a very important result that I am going to discuss later.

In order to understand the results better, I decided to divide each of the predictors' scores into quartiles based on the range of the *actual* results measured and not on the possible range, as the TPB advises. This will give me a better picture on the behavior of the teachers. (If I had had a larger population, I may have gotten results in the full range.)

Therefore, I repeated the steps described in Subsections 5.2.2 and 5.2.3, but with the quartiles according to the range of *measured scores*. The lower bound is the minimal score actually achieved for the predictor (instead of the minimal score that can be achieved) and the upper bound is the highest score actually achieved for the predicator (again, instead of the possible maximum score). In the following discussion I will refer these measurements as the *measured scores*.

Range according to measured scores in quartile

Indirect Attitudes

quartile	low	high
1st	201.28	245
2nd	161.52	201.27
3rd	121.76	161.51
4th	82	121.75

Indirect normative beliefs

quartile	low	high
1st	114.53	147
2nd	82.02	114.52
3rd	49.51	82.01
4th	17	49.5

Indirect perceived behavior control

quartile	low	high
1st	136.28	170
2nd	102.52	136.27
3rd	68.76	102.51
4th	35	68.75

Direct measures – perceived control

quartile	low	high
1st	6.1	7
2nd	5.18	6.09
3rd	4.26	5.17
4th	3.3	4.25

Direct measures – subjective norms

quartile	low	high
1st	4.33	5
2nd	3.65	4.32
3rd	2.97	3.64
4th	2.3	2.96

Direct measures – behavioral intentions

quartile	low	high
1st	5.5	7
2nd	4	5.49
3rd	2.5	3.99
4th	1	2.49

Scoring each of the members of group A according to the new quartiles

(n=6)

Teacher	Indirect attitudes	Direct subjective norms	Indirect normative beliefs	Direct perceived behavior control	Indirect perceived behavior control	direct intentions	Categories found from phenomenography
T1	1	1	4	1	3	1	Appropriation
T2	1	4	3	3	3	2	By-the-book
T3	1	1	1	1	3	1	Dissonant
T4	1	2	3	1	1	1	Appropriation
T5	1	1	3	1	4	1	Dissonant
T6	2	3	3	2	2	1	Shifted from Repudiation

Table-6 – The scoring of group A according to the measured scores

There are few differences between Table-5 and Table-6. For example, if we look at the columns "Direct subjective norms", "Indirect perceived behavior control" and "Direct perceived behavior control", in Table-6 we see a variety of scores as opposed to Table-5.

5.2.4 Low indirect perceived behavior control

The results of the TPB analysis showed low indirect perceived behavior control; most of the teachers were found in quartile 3 when I used the scale according to the TPB range. A similar result was found in Czerniak, Lumpe, Haney, and Beck (1999). In spite of the similar results, there is an important difference between the above study and mine. While they studied teachers who were *randomly selected* and with *no specific university degree* mentioned, my study deals with CS teachers, with at least a bachelor's degree in the subject, so we must assume that they are relative experts in employing computer technology. Therefore, it would be logical to expect that CS teachers should have *higher* perceived behavior control, but this is not the case.

There is also a difference between the educational technologies that the teachers employed in the two studies: Czerniak, Lumpe, Haney, and Beck looked at the general use of computers, while I looked at the use of a specific pedagogical system. In the rationale of my study I claimed that the group of CS teachers is different than other groups of teachers. The difference is that CS teachers are used to employing technology in their classes. The low perceived behavior control of CS teachers is evidence that this group should be investigated within the context of using a pedagogical tool. If CS teachers possess low perceived behavior control, then teachers from other disciplines who are not used to and trained to employ technology would certainly act similarly.

5.2.5 Reliability

The reliability of TPB computations was discussed in Subsection 3.2.2; these computations were performed on the data collected from the questionnaires. The results show that the direct measurement of perceived behavior control has the alpha value 0.6, which is as desired (Ajzen, 2002a), so this predictor can be considered reliable. I can increase the reliability of the predicator by omitting item 24[4] from the questionnaire, and then the alpha score becomes 0.79, as does the predictor of intention that was directly measured and whose alpha value is 0.95, which is very high. The direct measure of the normative beliefs has an alpha value of 0.6, therefore it could be considered as a reliable predictor. I can increase the reliability of the normative beliefs by omitting item 21[5]; then the alpha score is 0.72.

However, I do not wish to omit any of these items, and I am satisfied the reliability check as it is. The normative beliefs, which got the lowest reliability scores, give a good background on what the teacher feels but usually do not affect his/her intentions. The other two predictors are satisfactory according to TPB (Francis, Eccles et al., p. 30).

Correlations between the predictors

I calculated correlations across subjects (correlation of predictors of all subjects), as well as within subjects (correlation of predictors for each subject). I wanted to see whether there is a difference among the different profiles I created and the people that I think belong to the profile. This expanded my understanding of the subjects and increases the reliability to the results.

Table-7 presents the relevant findings. The numbers that appear in the cells are the correlations between the predictors appearing in the row and column of the cell. For example, the highlighted cell contains the number that is the correlation between attitudes (indirect) and subjective norms (direct). The correlations are calculated according to the Pearson correlation (other correlations gave similar results). In each cell, the number in the first row is the

[4] This item asks about direct PBC: "The decision to use an animation system in class is beyond my control". This item is very important therefore I decided not to omit it from the questionnaire.
[5] This item is: "My colleagues (Do/Do not) use an animation system in class". This item asks about normative beliefs. Since I am not referring to the normative beliefs later on I decided that this item is not very important.

correlation and the number in the second row is the significance of the correlation result. A significant result is marked in bold. The empty cells are those whose data can be found in cells that are symmetric about the main diagonal. The characters S, M and L stand for Small, Medium and Large respectively (according to Table-1).

(n=25)

	Attitudes indirect	Normative beliefs indirect	Perceived behavior control direct	Perceived behavior control indirect	Behavioral intentions direct
Subjective norms direct	M 0.342526 0.0937	M **0.467952** **0.0183**	M **0.48561** **0.0139**	-0.00399 0.9849	L **0.816281** **<0.0001**
Normative beliefs indirect	S 0.28041 0.1746	1	M **0.4797** **0.0152**	0.029859 0.8873	L **0.55612** **0.0039**
Perceived behavior control direct	S 0.132298 0.5284		1	-0.05711 0.7863	M **0.463442** **0.0196**
Perceived behavior control indirect	S 0.126741 0.5460			1	S 0.151386 0.4701
Behavioral intentions direct	M 0.35299 0.0835				1

Table-7 – correlations between each two predictors

According to Table-1 (Subsection 3.2.2.1) and Table-7, the correlation between the behavioral intentions and the subjective norms is large, as is the correlation between the behavioral intentions and the normative beliefs. These correlations are the significant ones.

The following correlations are marked as medium according to Table-1 and are significant too: subjective norms – normative beliefs; subjective norms – direct perceived behavior control; normative beliefs – direct perceived behavior control; behavioral intentions – direct perceived behavior control.

All other correlations are low or not significant.

According to TPB, I should have found significant correlation between the direct measurements and the indirect ones. The results show medium but significant correlation between the subjective norms and the normative beliefs which are the measurements of the same predictor (direct and indirect respectively). *The correlation between the direct and indirect measurements of perceived behavioral control is not only not significant but does not correlate at all.* This does not surprise me, because it says that there is a big difference between the way teachers explicitly say how they feel about using an animation system as a pedagogical tool and what they implicitly feel. Ajzen (2002b) says that a researcher may find no correlation between the results of the perceived behavior control, since people may find it difficult to accurately describe their beliefs (see Section 3.2.2).

I used two ways to check the reliability of my study, Cronbach's alpha that checked the reliability of each of the TPB predictors and correlations between each two predictors. As a whole I am satisfied from the results, especially in view of the small population, and I conclude that the questionnaire is reliable.

5.2.6 Validity

See Subsection 3.2.3

5.2.7 Descriptive statistics over all subjects

It is interesting to look at the descriptive statistics for the results and to use the quartiles and correlations to interpret them (Table-8). The numbers in the parentheses are the corresponding quartiles according to the measured scores.

Predictor	N	Mean	Std Dev	Median	Minimum	maximum
Attitudes indirect	25	197.4 (2)	34.9	203 (1)	82	242
Subjective norms direct	25	3.7 (2)	0.8	4 (2)	2.3	5
Normative beliefs indirect	25	60.6 (3)	31.2	59 (3)	17	147
Perceived behavior control direct	25	5.8 (2)	1.1	6.3 (1)	3.3	7
Perceived behavior control indirect	25	84.8 (3)	29.5	77 (3)	35	158
Behavioral intentions direct	25	5.2 (2)	1.9	6 (1)	1	7

Table-8 - Descriptive statistics over the respondents

According to the correlations found in the previous section, the behavioral intentions correlate well with the norms and the direct perceived behavior control. The mean value says that the teachers are in the second quartile (2), so they feel the social pressure to use Jeliot according to the norms (quartiles 2 and 3) and they say that they can control its use and have the ability to use it. One can see that the correlation between the direct perceived behavior control and the intentions is medium, so it is reasonable to conclude that teachers who have a high value for direct perceived behavior control are likely to have positive intentions (and conversely). But if we look at the indirect perceived behavior control, we can see that the mean is in quartile 3, which means that there is a problem in the control. The correlation between the intentions and the indirect perceived behavior control is small but not significant.

5.3 Back-to-Phenomenography – Predicting

5.3.1 Designing profiles

I defined ***profiles*** as an association of scores on the TPB questionnaire with the phenomenographic categories of the what-aspect. As a preliminary to describing the profiles, I discuss each of the predicators for each of the members in group A. I am using Table-4 and Table-6 to build the profiles.

5.3.1.1 Attitudes

T4 got the highest indirect attitude score (245 - in the Table-4 and 1 – in Table-6). I know the ways he uses Jeliot and they clearly place him in the Appropriation category.
T1 is the participant with a high indirect attitude score (242) in Table-4. T1 has good attitudes towards the use of animation as a pedagogical tool, and one can see that he is very close to the maximum TPB score (294).

T4 and T3 (indirect attitude score 237) are in favor of using an animation system as a pedagogical tool, but less than T1 and T4 (as can be seen in Table-4), but they are scored in the highest quartile (1) as T1 and T4 (Table-6).

T2 is in the high quartile (1 – Table-6) too, with an indirect attitude score a bit lower than T5 and T3 (217 – Table-4). T2 is not sure yet about the advantages of Jeliot when teaching her students. In the interview she said that there are students that—no matter what you do, even using animations—will not grasp an idea.

T6 is the participant with the lowest indirect attitude score (163 – Table-4, 2 – Table-6) with respect to the other members of group A. She showed rejection from the beginning when she was introduced to Jeliot. But she is still in the higher half of the spectrum (if we look at Table-4). I think that as time passed and in the view of the fact that she will have to teach Java, she might have softened her rejection. In the interview she said that one of the reasons that she did not use Jeliot was that her students did not know Java, and that if she would have had to teach Java then she might consider using Jeliot in class.

5.3.1.2 Subjective norms

T2 is the one who is the most resistant to social pressure: she does what she thinks is right to do as it concerns the use of an animation system. This can be seen from the low scores she got (2.3 – direct but 50 indirect – Table-4); therefore she is scored in the third quartile (4 and 3 respectively in Table-6).

T1 is very different; he says that he feels the pressure but the indirect measures show that he acts in the opposite way. T1 has high score in the direct measure (4.6 – Table-4), but a low score in the indirect measurements (17 – Table-4); therefore he is scored 1 and 4, respectively (Table-6).

T4 is in the middle (scores of 3.7 – direct and 57 indirect in Table-4, and scored 2 and 3, respectively, in Table-6). He is aware of public opinion about the use of the animation system and he knows how to deal with it. He does not ignore the pressure.

T6 is in the same quartile (3 in Table-6) with the scores 3.6 – direct and 66 – indirect in Table-4. Her indirect score is a bit higher than T4 and T5, which means that she also acts according to her own mind. This is true since I know that—although she did not like the idea of using Jeliot—she was obliged to do so by the school administration. One can see the difference between Table-5 and Table6: in Table-5 T6 and T4 got the same score, which demonstrates the reason for using Table-6 instead of Table-5.

T5 is in the middle of the range in Table-4; she got 4.6 in the direct and 60 in the indirect, which are a bit higher than T4 (1 and 3, respectively, in Table-6). This means that she is more affected by the social pressure than T4.

T3 is the participant who feels the most pressure to use the animation system. She is scored 1 – direct and 1 – indirect in Table-6, and the scores she got are 5 – direct and 147 – indirect in Table-4. We can see that her indirect score is very high relative to the other members of the group.

5.3.1.3 Perceived behavior control

The analysis shows (Table-5) that *none* of the respondents is scored in the highest quartile of the indirect measure (1), while most of them are in quartile 1 in the direct measure. Most of them can be found in the third quartile (3) in the indirect measure; therefore, I use the scores that appear in Table-4 in order to differentiate among the teachers. The 3 score indicates that using animation system in class has problems, and it is not smooth as could be wrongly assumed. This result is very important since we find here a group of teachers who are used to employ software in their classes, but, in spite of this fact, they face feelings of not being capable and of loss of control. I will discuss this result in the Discussion section (Subsection 6.3). The 3 score is the reason that I built Table-6 and, therefore, I am using the quartiles of Table-6 in the following analysis.

T4 is the one who shows the highest control. T4 got 7 for direct and 170 for indirect in Table-4 and can be found in quartile 1 for both direct and indirect in Table-6.

T6 gets the second high score of indirect perceived behavior control (108 in Table-4 and 2 in Table-6). But she is only in the middle relative to the other teachers in the direct measures (6 in Table-4 and 2 in Table-6). I am surprised at these high scores since she used Jeliot only when I came to visit and she did not hide the fact that she did not use Jeliot. I will expand on this below.

T1 is sure that he is capable of using an animation system, he sees no difficulties, and he believes that he can be in control while using it in class. This can be seen from the high scores that he gets (direct 6.6 and indirect 99 in Table-4, and the scores 1 and 3, respectively, in Table-6). I was surprised at the results of the indirect score, since I know that T1 used Jeliot for the whole year with his/her students and that he does not have any problems in using software tools. I decided to go back to the interviews and read them again.

T2 feels not in control according to the direct measurement (4.3 in Table-4 and 3 in Table-6), but the indirect measurement (89 in Table-4 and 3 in Table-6) shows a better picture. Although she is not confident while using Jeliot, when she uses it she feels in control. This is because she prepares herself for her classes and asked me for instruction on how to use Jeliot before employing it.

T3 shows the greatest control in the direct measurement (7 in Table-4 and 1 in Table-6), but very average control in the indirect measurement (73 in Table-4 and 3 in Table-6). This can be explained by the fact that she used Jeliot only at the end of the year when she did not have a choice; at that time she began to face problems such as installing the animation system and actually making her first steps in using it in class.

T5 thinks that she is in control in the direct measurements (6.3 in Table-4 and 1 in Table-6), but feels not in control relative to the others (49 in Table-4 and 4 in Table-6). She is very similar to T3 who started the use of Jeliot only at the end of the year.

5.3.1.4 Intentions

According to Tables-5 and 6, the scores indicate that most of the teachers (score 1) intend to use the animation system in class.

T5 and T3 show the highest intention (score 7 in Table-4). T1 (6 in Table-4), T6 (6 in Table-4) and T4 (5.6 in Table-4) intend to use it, but a bit less than T1 and T6. This is because the following year he will not teach Java. T2 got the lowest score on intention (4.3 in Table-4 and 2 in Table-6); she says that she will not use Jeliot the following year since she is going to teach C# and not Java.

T2 used Jeliot for demonstrations only, and she is concerned with how to use Jeliot (that supports Java) while teaching C# (another language similar to Java). She again feels less confident, as she was when she taught Pascal (another programming language). T2 needs time to adjust.

Although T5 and T3 got the highest scores, I know that they did not used Jeliot (in spite of their explicitly announcements) until they had no other choice! I will refer to this point below.

T6 has shifted from repudiating the animation system explicitly to announcing that she intends to use Jeliot next year. According to the TPB score of intention she intends to use Jeliot next year, and this corresponds with the interview, where she informed me that she did not use Jeliot because of the differences between the programming languages (Pascal was used in class, while Jeliot supports Java). I show later in Subsection 5.3.2.3 that T6 is classified as By-the-book according to the third prediction algorithm.

5.3.1.5 Profile of each teacher

I am using here the results of the phenomenographic phase on group A, as well as my personal acquaintance with each teacher in this group. The following profiles of the teachers deal with their intentions, normative beliefs and perceived behavior control as found in the TPB questionnaire. I am using Table-6 since in Table-5 most of the teachers can be found in the third quartile. The parentheses next to each teacher's name hold the phenomenographic categorization of the teacher.

T1 (Appropriation) is a teacher who is in favor of using an animation system in class. He is not affected of social pressure as can be seen in the indirect measures. Relative to his colleagues from group A, and in spite of the results of the TPB questionnaire, he says that he feels in control and confident while using the animation system in class, and that he intends to use it in the future. T1 actually used Jeliot quite a lot in his classes, and this correlates with the phenomenographic results of the study, but he used Jeliot in the manner he thought best for his students. It is possible that the low score of the indirect perceived behavior control refers to the fact that his students are problematic. Another explanation is that T1 is the only teacher from group A who did not have an instruction on how to use Jeliot. He chose to use Jeliot in a unique manner as he said that this is the only way his students would gain benefit from Jeliot. T1 was aware of other options of Jeliot but did not use them; this awareness made him feel that he was doing something wrong and this affected his score of indirect perceived behavior control.

T2 (By-the-book) is a teacher who is not sure that she is in favor of using an animation system in her classroom. She feels the social pressure to use it, but she decides for herself in spite of the pressure. She shows uncertainty in the use of the animation system relative to her colleagues in the group. She is very solid in her skeptical feelings. But there is a difference between the direct and the indirect *measurements* (not the quartiles) of perceived behavior control. She might be more in control than she thinks she would be. T2 used Jeliot for demonstrations in her class, and she asked me for help every time she encountered problems. But, when I came to class, she was prepared and used the animation system in the way she had been taught; she answered questions, and so on.

T3 (Dissonant) seems very much in favor of using Jeliot. She feels social pressure to use Jeliot and she responds to this pressure. Although she explicitly informed me that she is in control and that she is confident while using Jeliot, it is clear that she is the opposite way around. She answers that she will still continue to use the animation system even if her students are bored (all other teachers answered the opposite); this indicates her potential to be dissonant. T3 used the animation system only when I came to her class and she prepared herself for this session very well, but her students told me that that was the only time they saw Jeliot. She used to postpone or cancel my visits with a lot of excuses. However, when T3 had to express her intention, she said that she is going to use Jeliot.

T4 (Appropriation) got the highest score (Table-4) on the attitudes towards the use of Jeliot and he showed a lot of confidence and control while using it in class. He feels the pressure to use Jeliot but handles it very gently. T4 used Jeliot many times in his classes, in various ways; he even invented his own ways of using Jeliot (for inquiry). He controlled Jeliot and his classes involved Jeliot, and he knew exactly what option of Jeliot to use in his class when needed. T4 explicitly informed me that he intends to use Jeliot, but not in the following year, since he did not have classes that can be taught using Jeliot.

T5 (Dissonant) shows positive attitudes towards Jeliot. She feels social pressure to use Jeliot and reacts to it. In spite of her high score in direct measurements of behavior control, she gets the lowest scores in the indirect measurements. T5 was the only one in the group who scored in quartile 4 in this predictor. She says that Jeliot is not part of the curriculum that the laboratory is not fit to use Jeliot and that it might bore her strong students. T5 used Jeliot only on my visits, she came unprepared to class and she used Jeliot in an improper way that caused it not to execute the animation as she wanted it to. But on many occasions and in this questionnaire, she explicitly showed enthusiasm and made the listener feel that she uses Jeliot frequently.

T6 (Originally in the Repudiation category) is not in favor of using Jeliot in class as can be seen from her indirect measure of attitudes. She feels social pressure to use Jeliot, because of the fact that she did not have any other choice, she was obliged to teach with Jeliot. There is a difference between the measurements of direct and indirect perceived behavior control that I have already discussed above (Subsection 3.2.1.6). She shows confidence in using Jeliot and controlling it. She feels that she is in control and confident in spite of her attitudes. Her intentions are to use Jeliot in the future. In the interview she said that one of the disadvantages of Jeliot is that it supports Java and not Pascal (the programming language that she used in class), but now when she answered the questionnaire, she expressed positive intentions because next year she will teach Java. T6 is a teacher who showed rejection from the first time she used Jeliot and during the year that I observed her. I therefore was surprised at her future intentions. It is known from the literature (Tan & Forgasz, 2006) that when teachers are obliged (as T6 was obliged to use Jeliot) to use a technical tool, they find advantages in it no matter what they thoughts were before using it.
So far I have made a connection for each teacher between the phenomenographic categories that most describes him or her and the results of the TPB analysis of the teacher's own responses to the questionnaire. Now I am going to generalize these results in order to obtain a profile for each *category*.

5.3.1.6 Profile for each category

The phenomenographic phase resulted in an outcome space of four qualitatively ways that teachers experience using animation systems: Dissonant, Repudiation, By-the-book and Appropriation (Section 5.1.2). According to the results of the TPB study, I built a profile that characterizes a teacher who experiences the animation system in each of these ways. One might ask the reason for building these profiles. The answer can be found in the rationale of my study and in the literature review. Although I found both positive and negative ways that teachers experienced the use of animation systems, I intended to study the reasons *why* CS teachers prefer not to use animation systems, in spite of the encouraging results that show that the systems can help students overcome difficulties in their first steps in CS. The profiles will help associate teachers to the ways of experiencing and then the teachers with negative attitudes could be approached with a suitable treatment that might change their behavior.

5.3.1.6.1 The profile for a *dissonant* teacher

The dissonant teacher as found in the phenomenographic analysis (and as mentioned in the report of Naps et al., 2002) is a teacher who experiences the Jeliot animation system "in a conflicting manner: on the one hand with enthusiasm and on the other with a reluctance to actually use it." The dissonant teacher uses the system only when required, such as when someone comes to observe (use under compulsion).

According to the TPB measurements and according to the above characterization, when measuring the dissonant teacher's indirect attitudes and the direct intentions, he/she says that he/she is very much in favor of using an animation system. *But the indirect measurements will not correlate the direct ones*: the teacher's direct perceived behavior control will be high, but the indirect measurement will be very low. The high indirect attitude score is not surprising since it is based on the indirect questions that deal with the enthusiasm, but the indirect perceived behavior control deals with the factors that make the use of animation system easy or difficult. It is concerned with the teacher's ability or inability to work with the animation system, and also the control that the teacher feels that he/she has or the lack of the control while using the animation. As a result, I built the following profile. It is clear that the dissonant teacher will be aware of social pressure to use an animation system and that he/she is affected by this social pressure; therefore, both his/her direct and indirect subjective norms will be high or very high. Table-9 summarizes the attributes of a Dissonant teacher, where the numbers in parentheses give the quartiles of the predictors.

Predictor	Score
Indirect attitude	(1) Very high – very much in favor of using an animation system
Direct subjective norm	(2,3) Average – knows what is expected
Indirect normative beliefs	(1,2) High – feels a social pressure to use an animation system
Direct perceived control	(1,2) High – presents confidence and control about using an animation system
Indirect perceived control	(3,4) low – presents uncertainty of the tool, capability problems
Behavioral intentions	(1) Very high – explicitly expressing the intention to use an animation system

Table-9 – Profile of a Dissonant teacher

One can check and see that T3 and T5 are Dissonant by looking at the quartiles of each of these teachers in Table-6.

5.3.1.6.2 The profile for a teacher who *repudiates* the use of an animation system

The *Repudiation* category is the one above Dissonant in the outcome space of the phenomenographic phase. I defined a teacher who belongs to the Repudiation category as one who experiences an animation system "as an externally imposed tool of limited usefulness for teaching." This teacher "does not use the system at all; he/she is confident that the animation system is not a useful pedagogical tool."

According to the TPB measurements and according to the above characterization, when measuring the *repudiation* teacher's indirect attitudes and the direct intentions, he/she says that he/she is not in favor of using an animation system. *The indirect measurements should correspond to the direct ones*, since the repudiation teacher is aware of his/her thoughts, and, moreover, he/she is not afraid or ashamed to explicitly express those thoughts. The teacher's indirect attitude will be very low, but the indirect perceived behavior control could even be very high, since the teacher feels that he/she is capable of using the animation and has control over this behavior, but he/she thinks that the use of animation system is useless. It is clear that the repudiation teacher will be aware of social pressure to use an animation system and that he/she is affected by this social pressure; therefore, both his/her direct and indirect subjective norms will be high or very high, but we may find also that the teacher does not care about the social pressure. Table-10 summarizes the attributes of a Repudiation teacher.

Predictor	Score
Indirect attitude	(3,4) low – absolutely not in favor of using an animation system
Direct subjective norm	(1-4) not relevant
Indirect normative beliefs	(1-4) not relevant
Direct perceived control	(1,2) Average or high – presents confidence about the reasons for rejecting the use of an animation system
Indirect perceived control	(1,2) Average or high – presents certainty about the tool
Behavioral intentions	(3,4) low – explicitly expressing the rejection to use an animation system

Table-10 – Profile of a Repudiation teacher

No one in group A was at that point of time a teacher who was purely repudiating Jeliot. T6 is a teacher who used to be repudiating, as I know from the interviews both after the first time she was introduced to Jeliot and at the end of the year. The intentions that T6 expresses did not fit my profile. This was because of the time that passed between the interview and the questionnaire. T6 was obliged to use Jeliot in her school in spite of the rejection that she expressed during the first interview. The only times she used Jeliot were when I came to visit her in school and she said that too during the interview at the end of the year. The reasons for not using Jeliot were different between the two interviews. In the first interview, she referred to her role in class and to the characterization of her students. At the end of the year, she referred to the fact that Jeliot deals with the Java programming language while she is teaching the Pascal programming language. The interviews took place at the end of the 2004 school year and the TPB questionnaire was filled at the end of school year 2007. T6 will teach Java next year, and she intends to use Jeliot, at least according to her intentions in the TPB questionnaire. I think that T6 has shifted from the repudiation category to another one. This kind of shifting, caused by obligation, can be found also in the research of Tan and Forgasz (2006).

5.3.1.6.3 The profile for a teacher that uses an animation system *by-the-book*

The second category in the hierarchy is By-the-book. I defined a teacher who belongs to the By-the-book category as a teacher who experiences an animation system "as a possibly useful tool, but it may not fit with the teacher's pedagogical style." This teacher "works by the book; uses the animation system on special occasions such as teaching a new subject."

According to the TPB measurements and according to the above characterization, when measuring the *By-the-book* teacher's indirect attitudes and the direct intentions, he/she would be in the middle of the spectrum, since he/she has concerns about the benefits of the animation system, but he/she does not reject the use of the system automatically as the repudiation teacher would do. The teacher's indirect perceived behavior control will be scored average since he/she has still to make up his/her mind about using the animation; this also holds for his/her indirect perceived behavior control.

The By-the-book teacher prepares himself by asking questions about how to use the animation, confronting all possible obstacles that might occur while using the animation system in class. This leads to a good feeling while using the animation in class, but also to a situation where the teacher needs help from someone who is experienced; therefore, he/she may feel that he/she is not in control or that it is difficult for him to handle the animation system. From this I concluded that the direct perceived behavior control score would be average or low, but the indirect measurements of this predictor might be average.

This is also a reason for the average intentions to use the animation system; the teacher has to prepare himself for every possible scenario that might be in class since animation systems are "living things."

The By-the-book teacher will be aware of social pressure to use an animation system and he/she is affected by this social pressure; therefore, both his/her direct and indirect subjective norms will be high or very high, but like the rejection teacher he/she may ignore this pressure. Table-11 summarizes the attributes of a By-the-book teacher.

Predictor	**Score**
Indirect attitude	(1,2) Average or higher – not in favor of using an animation system but no rejecting it
Direct subjective norm	(1-4) not relevant
Indirect normative beliefs	(1-4) not relevant
Direct perceived control	(3,4) Average or low – not sure about using the animation system and therefore lack of confidence in engaging it into class
Indirect perceived control	(2,3) Average – the teacher who is aware of his/her control problem prepares himself to class and gains control
Behavioral intentions	(2,3) Average or low – explicitly expressing the fact that they are willing to try but not sure about the frequency and how use it

Table-11 – Profile of a By-the-book teacher

One can see that T2 (according to Table-6) is a teacher who belongs to the By-the-book category. From interviews and observations I knew that she is skeptical about the benefits of

Jeliot. She used Jeliot as she was taught, and whenever she had problems she contacted me for help. She is very cautious while using Jeliot, and she does everything by-the-book (as I tell her). She is aware of the social pressure to use Jeliot, but it does not affect her, because she knows that what she is doing is the best that she can achieve.

5.3.1.6.4 The profile for a teacher who *appropriates* the use of an animation system

This is the highest category of experiencing an animation system. I defined a teacher who belongs to the Appropriation category as a teacher who experiences an animation system "as a useful tool consistent with the teacher's pedagogical style. This teacher frequently uses animation, uses novel methods and uses it for inquiry. The teacher who experiences the animation system in this way integrates it into classroom activities."

According to the TPB measurements and according to the above characterization, it is reasonable that when measuring the *Appropriation* teacher's indirect attitudes and the direct intentions, he/she would score very high, since he/she is confident that the animation system is beneficial and that he/she can use it as he/she would like to. The teacher's indirect attitude will be scored very high, since he/she would be very much in favor of using it in class. We see not only that he/she uses the animation system frequently and controls the system, but also that he/she finds novel methods to do so.

The indirect and direct perceived behavior control should be very high, too, but as I mentioned before, most of group A's members have the score 3 which is less than average. When comparing the scores, the Appropriation teachers should have the highest scores in this predicator. From Table-6, we can see that T4 is a teacher who belongs to this category.

Predictor	**Score**
Indirect attitude	(1) Very high – absolutely in favor of using an animation system
Direct subjective norm	(1-4) not relevant
Indirect normative beliefs	(1-4) not relevant
Direct perceived control	(1) Very high – presents confidence about the using of an animation system
Indirect perceived control	(1,2) High – presents certainty about the tool, being sure of the way to use it and feel that he/she is in control while using it
Behavioral intentions	(1,2) High – explicitly expressing the he/she is going to use an animation system

Table-12 – Profile of an Appropriation teacher

It is clear that the Appropriation teacher will be aware of social pressure to use an animation system and that he/she is affected by this social pressure; therefore, both his/her direct and indirect subjective norms will be high or very high, but like the Repudiation teacher he/she may ignore this pressure. Table-12 summarizes the attributes of an Appropriation teacher.

One can check Table-6 and see that T4 is in the category of Appropriation. As a matter of fact T1 is also categorized under this category (from the phenomenographic phase), but the results I got were incompatible with the definition of the Appropriation category according to the profile of TPB. This incompatibility will be discussed later in this chapter.

5.3.2 Designing algorithms for associating teachers to profiles

After defining profiles for each of the categories found in the phenomenographic phase, I associated teachers with the profiles according to their scores resulted from the TPB analysis of the questionnaires they filled in. I designed several algorithms to compute the predictions. In the algorithms, I did not use the values of the normative beliefs or the subjective norms, since—as apparent from the data—they did not affect the teachers' attitudes towards the use Jeliot.

Table-13 shows the profiles that I described in Subsection 5.3.1.6 (Tables 9–12). The colored cells are discussed below in algorithm 3.

Predictors	Appropriation	By-the-book	Repudiation	Dissonant
Indirect attitudes	1	1,2	3,4	1
Direct subjective norms	1-4	1-4	1-4	2,3
Indirect normative beliefs	1-4	1-4	1-4	1,2
Direct perceived behavior control	1	3,4	1,2	1,2
Indirect perceived behavior control	1,2	2,3	1,2	3,4
Direct behavioral intentions	1,2	2,3	3,4	1

Table-13 – Profiles

5.3.2.1 Algorithm 1 – classify according to the defined profiles– *pure attachment*

In this algorithm, *all* values of predictors correspond to the profiles I defined above. Here are examples of teachers from the TPB population that were classified according to this algorithm.

T7 can be classified as an **Appropriation** teacher and the following Table-14 describes the values of the TPB predictors according to the teacher's questionnaire:

predictor	value
Indirect attitudes	1
Direct subjective norms	2
Indirect normative beliefs	3
Direct perceived behavior control	1
Indirect perceived behavior control	1
Direct behavioral intentions	1

Table-14 – Example of the values of the TPB predictors for an Appropriate teacher

T8 can be classified as a **By-the-book** teacher and the following Table-15 describes the values of the TPB predictors according to the teacher's questionnaire:

predictor	value
Indirect attitudes	2
Direct subjective norms	3
Indirect normative beliefs	4
Direct perceived behavior control	4
Indirect perceived behavior control	3
Direct behavioral intentions	2

Table-15 – Example of the values of the TPB predictors for a By-the-book teacher

None of the teachers fits the **Repudiation** category.

T9 can be classified as a **Dissonant** teacher and the following Table-16 describes the values that the TPB predictors according to the teacher's questionnaire:

predictor	value
Indirect attitudes	1
Direct subjective norms	2
Indirect normative beliefs	3
Direct perceived behavior control	1
Indirect perceived behavior control	3
Direct behavioral intentions	1

Table-16 – Example of the values of the TPB predictors for a Dissonant teacher

The result of this algorithm was:

Appropriation –T4, T7, T10

By-the-book – T2, T8

Repudiation – none

Dissonant – T3, T5, T9, T11, T12

Not classified – the other 15 teachers.

Total number of teacher classified is 10 out of 25. The algorithm is obviously unsatisfactory since it failed to classify most of the teachers.

5.3.2.2 Algorithm No. 2 – classify according to *a numerical algorithm*

This algorithm is based on the sum of all the scores for each predictor for each profile. The idea is to sum the scores of each teacher and to associate a profile to the teacher according to the range of the sum. For each profile, I calculated the minimum value that the sum of predictors should get to and the maximum value as well. I give here the calculations of the bounds of each profile. The results of all the profiles will be given afterwards.

Calculation of the values of the Appropriation profile bounds

The following Table-17 describes the minimum and maximum values that each predictor has. When a predictor may have two values, the minimum is taken according to the minimum value of the lower bound and the maximum is taken from the maximum value of the upper bound. The number in the parentheses gives the quartile number from which these minima and maxima are taken.

Predictor	Value	Minimum	Maximum
Indirect attitudes	1	201.28	245
Direct perceived behavior control	1	6.1	7
Indirect perceived behavior control	1,2	102.52 (2)	170 (1)
Direct behavioral intentions	1,2	4 (2)	7 (1)
Total sum		313.9	429

Table-17 - Appropriation profile bounds

Calculation of the values of the By-the-book profile bounds

Predictor	Value	Minimum	Maximum
Indirect attitudes	1,2	161.52 (2)	245 (1)
Direct perceived behavior control	3,4	3.3 (4)	5.17 (3)
Indirect perceived behavior control	2,3	68.76 (3)	136.27 (2)
Direct behavioral intentions	2,3	2.5 (3)	5.49 (2)
Total sum		236.08	391.93

Table-18 – By-the-book profile bounds

Calculation of the values of the Repudiation profile bounds

Predictor	Value	Minimum	Maximum
Indirect attitudes	3,4	82 (4)	161.51 (3)
Direct perceived behavior control	1,2	5.18 (2)	7 (1)
Indirect perceived behavior control	1,2	102.52 (2)	170 (1)
Direct behavioral intentions	3,4	1 (4)	3.99 (3)
Total sum		190.7	342.5

Table-19 – Repudiation profile bounds

Calculation of the values of the Dissonant profile bounds

Predictor	Value	Minimum	Maximum
Indirect attitudes	1	201.28	245
Direct perceived behavior control	1,2	5.18 (2)	7 (1)
Indirect perceived behavior control	3,4	35 (4)	102.51 (3)
Direct behavioral intentions	1	5.5	7
Total sum		246.96	361.51

Table-20 – Dissonant profile bounds

After calculating the bounds of each profile, I classified the subjects according to the bounds. The graph below describes the profiles according to their range of values as calculated earlier.

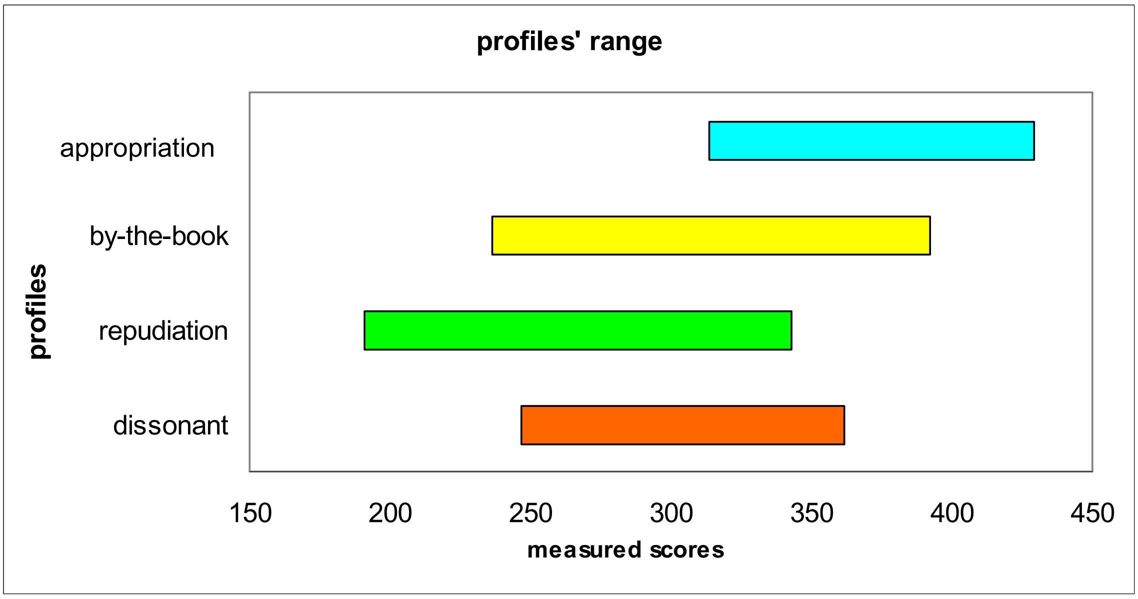

Figure-8 – The results of the numerical algorithm

The results cannot be used for classification because, as one can see in Figure-8, there is much overlap among the ranges. For this reason I abandoned the algorithm.

5.3.2.3 Algorithm no. 3 – classify according to *differences*

This algorithm is based upon the differences among the profiles' characterizations. Algorithm 1 dealt with the values of all the predictors, while this algorithm minimizes the number of predictors evaluated in order to make classifications. I refer now to the colors of Table-13. For each category (column), I colored the cells that are sufficient to classify a teacher under this category.

The algorithm is as follows:

In order to classify a teacher as **appropriation**:

indirect attitudes should be 1 and indirect perceived behavior control 1

or

indirect attitudes should 1, indirect perceived behavior control 2 and direct perceived behavior control 1.

In order to classify a teacher as **by-the-book**:

indirect attitudes should be 2

or

indirect attitudes should be 1, the indirect perceived behavior control 3 and direct perceived behavior control 3 or 4.

In order to classify a teacher as **dissonant**:

indirect attitudes should be 1 and the indirect perceived behavior control 4

or

indirect attitudes should be 1, the indirect perceived behavior control 3 and direct perceived behavior control 1 or 2.

In order to classify a teacher as **repudiation**:

indirect attitudes should be 3 or 4

The result of this algorithm was:

Appropriation –T4, T7, T10

By-the-book – T2, T6, T13, T14, T15, T8, T16, T17, T18, T19, T20, T21

Repudiation – T22, T23

Dissonant – T1, T3, T5, T24, T9, T11, T12

Not classified – only 1 teacher.

Total number of teacher classified is 24 out of 25.

The reason for the change in the number of teachers classified can be attributed to the fact that I looked for the *significant differences* among the predictors of the profiles. In this way I could classify teachers to the closest profile that characterized them.

5.3.3 Revisiting the dissonant category

According to the phenomenographic analysis, the dissonant category concerns teachers who experienced the use of an animation system with two aspects simultaneously: enthusiasm towards the use of the system and reluctance to use it. The teachers who experienced the use of animation in this way were T3 and T5 from group A.

The TPB phase provided profiles that characterize teachers who match the four categories of description found in the phenomenographic phase. The "classify according to differences" algorithm classified both T3 and T5 to be dissonants, but T1 was classified as dissonant, too. This was a surprise to me since I considered T1 to be an Appropriation teacher.

During the TPB phase I met two new teachers T11 and T25 who used the animation system during a full school year.[6] I interviewed both of them according to the phenomenographic tradition, although it was impossible to observe their lessons. According to their phenomenographic interviews, I categorized these teachers as by-the-book, since they experienced simultaneously several aspects. They thought that the animation may be a useful tool, but T25 used it with another tool, and, more importantly, T25 used it only for explanations of difficult concepts, where she thought that the use of Jeliot is crucial for the understanding of the students. She needed more options than Jeliot could provide her, options that only more advanced students would need, and not novices. T11, on the other hand, used Jeliot as a working environment, but was not aware of features of the animation system designed for helping students understand the execution of programs, and therefore did not use it for that purpose in class.

T11 and T25 filled in the TPB questionnaire, and, surprisingly, both were classified as dissonant according to the "classify according to differences" algorithm. Again, I found it rather disconcerting to classify a teacher as dissonant according the TPB, while from phenomenography, they were clearly appropriation or by-the-book. In order to understand this anomaly, I returned to phenomenography again, this time with the *focus on the tool* (Jeliot). I analyzed quotations on the advantages, disadvantages and use of the tool in order to get a better understanding. Of course, I could not get new categories from the analysis, since the

[6] Teacher T25 was a participant who was not a member in any of the groups of the research population. This teacher contacted me after all the data was analyzed, but I interviewed her anyway and asked her to fill in the TPB questionnaire. She can be viewed as an example of how the tools I developed can be used in the future to predict the behavior of teachers.

focus of the phenomenographic phase of the study was on the teachers, and I reached saturation of the categories in the initial analysis. However, the new phenomenographic analysis resulted in further insight into teachers who experienced the animation system as Dissonant.

I isolated the five teachers for whom I had phenomenographic interviews, and who were classified as Dissonant according to the TPB algorithm. I found two subgroups: T3 and T5 were in one subgroup because they were classified as Dissonant according to both phenomenography and the TPB algorithms. The second subgroup consisted of T1, T11 and T25 who were classified as Appropriation or By-the-book by phenomenography and Dissonant by the TPB algorithms.

The main difference between the two subgroups is grounded in the course on Jeliot: T3 and T5 attended a course while the other three did not. The "real" dissonant teachers, T3 and T5, chose not use Jeliot, but did not say so explicitly; moreover, they said that they used it but they did not. On the other hand, T1, T11 and T25 used Jeliot but faced control problems that could have been avoided if they had participated in a course on Jeliot; therefore, there was a difference between their positive attitudes towards the use of an animation system and their low perceived behavior control.

Other differences were found in the phenomenographic interviews; most were connected with the *use* of the animation system. The following Table-21 summarizes the differences between the two subgroups. The *Aspect* column describes a quotation from the interviews and observations during the phenomenographic phase, and the next two columns refer to each of the subgroups. The mark ✓ indicates that one of the teachers from the above subgroup used the quotation that appears in the current line.

Table-21 shows the different manners of using Jeliot between the two groups. From the Table, it can be mistakenly concluded that these teachers are Appropriation or By-the-book, since all of them (in both columns) describe how they *use* Jeliot. But, the real picture is different. T3 and T5, who were under my observation as members of group A, avoided the use of animation as much as possible. They used Jeliot only when I came to observe them, while T1, T11 and T25 used Jeliot by themselves. I was able to establish because: T1 was a subject in group A who was under my observation during a full year, T11 was in touch with me during the year, and T25 was the one who called me to ask for help on using Jeliot in an advanced course in CS.

Aspect	T3 and T5	T1, T11 and T25
Use the tool to present new topics	✓	
Use when I feel it is necessary – for explanations, for difficult topics		✓
Use when I want to attract my students	✓	
I use it as I was taught in your course	✓	
I choose how to use the animation in class		✓
I use it because other do	✓	
I used ready made examples only	✓	
I used ready made examples and adjusted them to my needs		✓
I had to prepare a lot before class		✓
I have built the example with the students (came unprepared to class)	✓	

Table-21 The difference between the two Dissonant subgroups

T1, T11 and T25 did not participate in a Jeliot course, nor did they have private lessons from me as did the teachers from group A. Therefore, they used Jeliot as they found it necessary, and they faced problems that Appropriation teachers did not experience and that By-the-book teachers did not face. In spite of the fact that these teachers got assistance from me, they felt that they were not in control, since they had to ask questions that could have been avoided if they had had a course. T1 did not ask questions; he faced and tried to overcome the problems by himself. This, I think, is the reason that the TPB phase diagnosed him as dissonant. The problems that these teachers faced caused them to feel not in control, in spite of the fact that they had high attitudes. The combination of low perceived behavior control and high attitudes is indicative of a dissonant teacher according to the allocation algorithm, and that is the reason for them being classified as dissonant.

6. DISCUSSION

The literature review in the chapter on the background showed that among the reasons for unsuccessful reforms we can find the teachers' reluctance or inability to carry out the reforms. Being a teacher, I was dissatisfied with the fact that the behavior of the teachers is one of those reasons. Being a CS teacher who has used animation as a pedagogical tool over a decade, I felt that something is wrong with the fact that the use of animation systems is not widespread. Finally, being a researcher who was involved in characterizing a software tool for use in teaching and learning, and the encouraging results of studying the effects that animation systems have on students, I was disappointed to discover that there is a reluctance to use an animation system as a pedagogical tool, especially by CS teachers. I believe that studying the reluctance of CS teachers gives a new view of the reasons of not using software tools, not only by CS teachers but also by teachers from other disciplines.

6.1 Choosing the Methodology

In order to conduct this study I had to choose a methodology. Since I did not have a firm idea— except for a general one— of what form the results could take, I decided to use one of the qualitative research methods. The qualitative methods I considered were *grounded theory* (Glasser & Strauss, 1967) and *phenomenography* (Marton, 1986; Marton & Booth, 1997). These methods are similar in that they involve observations and interviews whose transcripts are then analyzed in great detail by encoding and categorization. Nevertheless, there are significant differences among them. The goal of grounded theory is to construct a theory that can be used to *explain* people's behavior in a certain context; therefore, grounded theory looks for *causes*. On the other hand, the goal of phenomenography is to describe the possible *variation* in behavior and understanding without looking for causes. Initially, I wished to investigate teachers' conceptions and understanding of the animation system as a pedagogical tool, so phenomenography was the natural choice. In addition, Booth's pioneering use of phenomenography in CS education had brought it to a prominent position as a research framework in our community, and I wished to try phenomenography for myself.

As my research progressed, I decided that it was important to focus on the *negative* ways of experiencing and on the causes of the rejection, so I had to choose another methodology for the second phase. Since it had become apparent that the rejection was caused by negative attitudes, it was natural to investigate these directly. This led me to the discipline of *social psychology*, which deals with the relevant concepts like attitudes and behavior. The textbook by Baron and Byrne (1987) served as an introduction to theories concerning attitudes and behavior, and a further literature search led me to choose the theory of planned behavior as the one most appropriate for my needs. The reason is that TPB enables *prediction* of behavior from attitudes and this matched my need to predict teachers' rejection of the animation system already from an initial encounter.

Mixed research methods are described in Johnson and Christensen (2004). The qualitative research and the quantitative research are conducted either concurrently or sequentially to address the research topic (p. 48). In my case, it was sequentially and *circularly*, since I started with phenomenography (the first phase), continued with TPB (the second phase) and then went back to phenomenography (the third phase). As written in the book, when I looked at the results I found that the two research approaches complemented each other. A fundamental principle of mixed research is to mix methodologies in a way that the resulting mixture or combination has complementary strengths (Brewer & Hunter, 1989; Johnson & Turner, 2002).

Phenomenography was used to find out how teachers experience the use of Jeliot as a pedagogical tool. Since I found that many teachers reject the tool, I decided to investigate the teachers' attitudes. But, phenomenography is not the appropriate methodology for investigating attitudes. Moreover, phenomenography does not deal with individuals. On the contrary, the outcome space that is the result of a phenomenographic study gives information on the collective level of the population, while I was interested in the individuals' attitudes. The TPB methodology helped me find the attitudes that teachers, as individuals, possess towards the use of Jeliot. The data for the TPB analysis was based upon the interviews and observations from the phenomenographic phase. Therefore, I could later go back to the results of phenomenography in order to generalize my findings from the TPB phase. An important result I found was that the group of Dissonant teachers was divided into two subgroups; this division would not have been found unless I had integrated the two methodologies.

6.2 The Phenomenographic Outcome Space

The result of the phenomenographic phase of my study was a hierarchically ordered set of categories that are the ways of experiencing the phenomenon under observation. I focused on teachers' ways of experiencing the Jeliot animation system and found four ways of experiencing the animation system as a pedagogical tool. I had expected that there would be two main categories, one for teachers who tend to accept the use of Jeliot and another for those who tend to reject Jeliot. The phenomenographic analysis of the data in this phase refined these two categories.

The acceptance of Jeliot was divided into two categories: Appropriation and By-the-book. These two categories seem natural to me since the first represents the teachers who were very much affected by Jeliot, while the second category is for the teachers who follow the instructions in an algorithmic way.

The rejection of Jeliot was divided into two categories: Repudiation and Dissonant. The Repudiation category is natural, too, since it represents the teachers who refused to use the software tool. While the first three categories are not surprising and even seem natural, the discovery of the Dissonant category was a surprise to me. I had expected that every teacher would experience the use of Jeliot either positively or negatively, but not a "combination" of positive enthusiasm together with negative reluctance in the same context.

The TPB phase of my study discovered the attitudes that CS teachers possess towards the use of the Jeliot animation system as a pedagogical tool. The results show that—in general—CS teachers possess high attitudes and high intentions towards the use of animation as a pedagogical tool. However, in spite of the high scores they got for the measurements of *direct* perceived behavioral control, they got low scores for the measurement of the indirect perceived behavior control. This can explain the low rate of using such tools in practice.

6.3 Low Indirect Perceived Behavior Control

The most striking result is the low scores of indirect perceived behavior control among most teachers; the average score 85.8 is found in the third quartile. This is very surprising since the indirect PBC measures the degree of to which the teacher feels confident and in control when using an animation system. I did not expect this low score given that CS educators *routinely* use software tools such as advanced programming environments in their classrooms, and that their CS training certainly requires intensive use of software tools. I believe that the low level of indirect perceived behavior control is caused, paradoxically, by the strengths associated with the pedagogical software: since the software is successful at explaining concepts and facilitating learning, it can be threatening to the *centrality of the educator* in the classroom. CS teachers are reluctant to admit that they are threatened by computing technology, since the normative beliefs of people in general are that CS teachers are experts in using the technology. Therefore, their reluctance will not appear in a direct measurement, but only in an indirect one. In Chapter 7 I give some advice on how to deal with the issue of low indirect PBC.

6.4 The Dissonant Way of Experiencing

During the phenomenographic analysis, I uncovered a way of experiencing that I called the *Dissonant* category. There are two issues that were raised concerning this category:

1. Is it possible that Dissonant is not a separate category, but rather should be considered as the simultaneous experience of two other categories: By-the-book and Repudiation? The teacher expresses positive attitudes towards the animation system and thus his/her way of experiencing is similar to that of By-the-book, but he/she refuses to use the system, as in Repudiation.
2. How does the category fit within the hierarchy of categories?

6.4.1 Dissonant is a way of experiencing

In Subsection 3.1.4 I gave several citations from the developers of phenomenography; from those citations it is clear that a specific way of experiencing a phenomenon exists when the individual is focally aware of one aspect or simultaneously aware of several aspects of it. Therefore, the Dissonant category *is* a way of experiencing since it describes different aspects that are *simultaneously* experienced by an individual: enthusiasm and rejection.

In my study, a Dissonant teacher said: “Jeliot is *great* [my emphasis] for teaching everything” and he said that uses Jeliot in class, but immediately added that “Jeliot is problematic since it makes a lot of mistakes.” The last statement was the teacher’s excuse since she came unprepared to class and did not know how to operate Jeliot. Later in the interview, the teacher said that she does not need an assistant and that using Jeliot takes a lot of time. From the example, we see that this individual experiences Jeliot in a way that results from focusing on these two aspects *simultaneously*. Dissonant cannot be considered as a combination of two separate ways of experiencing, since the statements were recorded in a single context (the teacher-training course),

When Marton discusses individuals experiencing a phenomenon in more than one way, he refers to *different occasions and situations* (Marton, 1981, p. 177; Pang, 2003, p. 150). I, too, found that teachers can experience Jeliot in more that one way in different contexts. For example, a teacher thinks that Jeliot is “great” for studying constructors in Java (which is a difficult concept); therefore, in that context, he/she experiences Jeliot in the category By-the-book (or even Appropriation). The same teacher may think that Jeliot is not beneficial at all for studying loops (since it is very easy); therefore, in that context, he/she would experience Jeliot in the category Repudiation. These are two different contexts, since they deal with different situations arising from the different subject matter that is taught.

Analogously, the person who was raised near the forest (Subsection 3.1.4) may not be afraid of a deer when he/she meets it in the daylight (this is one context), but may be afraid when the meeting happens at night (this is another context). The same person experiences the deer in two different ways, but the context (day or night) is different.

I conclude that Dissonant is a separate way of experiencing, because a person is *simultaneously* focally aware of two opposite ways of thinking—positive and negative. The teachers show enthusiasm and rejection at the same time, and this experience cannot be separated into two different occasions or situations (contexts). These individuals could not bring themselves to admit that they reject the system for their own reasons; they explicitly say that they use the system when they actually don't do so and they are *aware* of this contradiction.

6.4.2 The place of the Dissonant category in the hierarchy

In Subsection 5.1.4, I gave three hierarchical orders of the outcome space I found. The Dissonant category is placed at the bottom of the hierarchy in all the orders that I defined. In the Inclusive hierarchy, the Dissonant category is defined as a "Bad rejection," which means that the teachers who experienced Jeliot in this way did not have any pedagogical explanation for the rejection as did the teachers in the Repudiation category. The addition of the explanation means that the Repudiation category includes the Dissonant category. When trying to explain the order of the Inclusive hierarchy, I defined the rejection analogously to the empty set in mathematics. I believe that this is an artificial explanation, so I do not like this hierarchy.

The second hierarchy I showed was the Linear one, where the categories are used as borders in the spectrum of ways of experiencing a phenomenon. In this hierarchy a teacher can be associated with categories and also belong somewhere between two adjacent categories. This is a more appropriate order for the four ways of experiencing, especially after I defined the profiles and the third algorithm to associate teachers to ways of experiencing. In the third algorithm, I defined the predictors and their values in order to do this association. With this algorithm I could associate 24 out of 25 teachers to the profiles I defined.

The third hierarchy is a combination of the Inclusive and the Linear hierarchies. This hierarchy does not have continuity between pairs of categories, but is defined in terms of separate attributes of the teachers. In this hierarchy the Dissonant category is almost separate from the others, but it has much in common with the Repudiation category. This hierarchy is based upon the role of the teacher in class and the categories found. It is less than an ideal hierarchy since we have a combination of more than one aspect. The categories depend upon both the centrality issue and the degree of the use of the animation system; these two aspects are intertwined and therefore affect each other. This connection can be explained as the connection between the beliefs (centrality) and the behavior (the degree of the use of Jeliot).

I prefer the Linear hierarchy, since it describes the results of my study better than the Inclusive hierarchy that I consider to be an artificial description of the order within the categories. The third hierarchy is based on how a teacher perceives his/her role in the class. Therefore, although this hierarchy describes the same order within the categories, it is different from the first two hierarchies. The third hierarchy gives another view on the results and led me to search for a connection between PBC to the centrality of the teacher. The dissonant way of experiencing fits within all hierarchies.

6.4.3 Evaluating Dissonant as a way of experiencing

There are certain criteria for assessing the *quality* of the categories (Marton & Booth, 1997, p. 125-128):

1. Each category tells something about a way of experiencing the phenomenon;
2. There is a relationship among categories—frequently it is a hierarchical;
3. The number of categories is low but covers all the data (parsimonious).

The first criterion evaluates the ways of experiencing. The Dissonant category is a way of experiencing according to the rule of several aspects that are being discerned simultaneously. These aspects are enthusiasm for the system intertwined with rejection of it for the teachers' own reasons. These two aspects cannot be separated because they exist at the same time and in the same context. This is not the situation of one teacher experiencing Jeliot in two ways of experiencing, since as I showed before this can happen when the same teacher experiences Jeliot in different contexts. Therefore, Dissonant is a separate way of experiencing.

According the second criterion, the Dissonant category can be placed into a relationship with the other categories. Although an inclusive hierarchy is possible, I prefer the linear one, as discussed in the previous Subsection.

For the third criterion, there is not much to choose in parsimony between three and four categories; nevertheless, I have shown that the Dissonant category is necessary to cover all the data.

6.5 Two Subgroups in the Dissonant Category

I found two subgroups of teachers who received very high scores for attitudes and low scores for indirect perceived behavior control. Teachers with this set of predictors were classified as Dissonant according to my TPB profiles. The two subgroups differed in that the teachers in one subgroup (Dis1) used the animation tool, while the teachers in the other one (Dis2) did not. Since a reluctance to use the tool is characteristic of Dissonant teachers (see Table-9), this meant that only the subgroup Dis2 should be classified in this category.

Why do the teachers of the Dis1 subgroup answer the TBP questionnaire like Dissonant teachers? A re-examination of the interviews used in the phenomenographic study revealed that these teachers learned to use the animation tool *by themselves*, without participating in a training session. They used the tool successfully, but in their own idiosyncratic ways; eventually, they faced control problems that can affect the way they experience the use of the tool and the attitudes they possess towards it. In the interviews, I found that the characteristic behavior of the teachers in this subgroup was their persistence in using the tool. However, other teachers facing similar control problems might be less persistent, and then they would answer the questionnaire in a manner that would classify them as Repudiation.

These teachers experience the animation tool somewhere in the spectrum of the hierarchy between Appropriation (because of the high level of attitudes) and By-the-book (because of the low perceived behavior control). The teachers still have high attitudes and they are persistent in the use of Jeliot and in trying to improve themselves. This is consistent with the framework of phenomenography that allows a single subject to experience a phenomenon in more than one way in *different contexts*. The fact that they answered the questionnaire as Dissonant shows that TPB by itself may not be sufficient to diagnose a teacher's attitudes and should be supplemented by qualitative tools like interviews. In the next chapter I suggest several ways to approach the teachers from Dis1 and Dis2.

6.6 A Meta-View of My Study

There were three phases in my study. The phenomenographic phase provided a description on how teachers experience the use of an animation system as a pedagogical tool; the TPB phase provided the means to predict the way that a teacher would experience an animation system; the third phase provided a profile for each way of experiencing in order to predict the behavior of CS teachers. The algorithms that I developed in the third phase can be used to associate teachers with the profiles in order to address the teachers in a course to avoid negative ways of experiencing.

A course that introduces a software tool usually deals with how to install the tool and how to use it. The course rarely deals with the attitudes that the students in the course possess. The following Figure-9 shows a model that I propose for connecting the ways of experiencing I found with the predictors of the TPB:

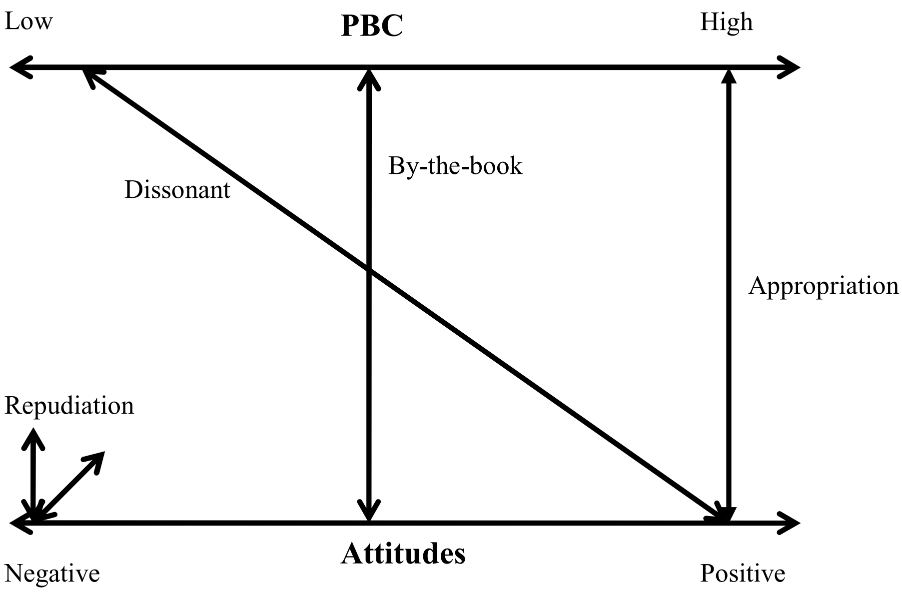

Figure-9 PBC and Attitudes

The model consists of two horizontal axes. The upper axis (labeled PBC) describes the TPB scores for indirect perceived behavior control, from very low to very high; they are marked Low and High, respectively. The lower axis (labeled Attitudes) describes the TPB scores for indirect attitudes from negative attitudes (very low scores) to the positive ones (very high scores). The labels on the vertical arrows and on the sloped ones are the names of the categories found in the phenomenographic phase. The Appropriation category is described as a correspondence between Positive attitudes and High PBC, as described in the profile of a "pure" teacher who belongs to this category according to the "pure attachment" classification algorithm. The By-the-book category is described by an arrow in the middle between attitudes and PBC; this can be described as well by the profile and the algorithm. It is interesting to see that the Repudiation category is placed at the Negative attitudes; the direction of the arrow towards the PBC axis does not matter, since a teacher who is in the Repudiation category possesses negative attitudes no matter what the PBC level he/she is in. The third algorithm associates teachers with the Repudiation category just from the low attitudes. The profile for the Dissonant teacher suggests a connection between High attitudes and a very low score for PBC.

According to this model not only can we predict the way of experiencing, but we can also understand that changing attitudes may change behavior, as claimed by TPB. A course usually deals with how to use a tool, not with attitudes or with the way teachers feel about being able to control the tool and being able to use it properly. We can see from the model that if a teacher changes his/her attitudes from negative towards positive ones, he/she could be shifted from Repudiation to By-the-book or to Appropriation, or worse to Dissonant. It is a matter of the awareness of the people who give the course, and for this reason *prediction* is so important.

In the Background chapter I found that the centrality of the teachers is very important for the success of reforms. For example, Agudelo-Valderrama, Clarke, and Bishop (2007) tried to understand why teachers do not change their practice according to the demands of the intended curriculum. They found that making the change depended upon the *attitudes* that the teachers possess towards the new curriculum and their own *role* in the classroom. Moreover, they found that the more self-efficacy the teachers believed they had, the more they would be willing to make the change. This, together with the model I described above led me to the following model. This model describes the connection between PBC and Centrality.

The results of the phenomenographic phase of my study yielded four ways of experiencing an animation system as a pedagogical tool. I have ordered this outcome space in a Linear-Inclusive hierarchical manner (Subsection 5.1.4.3), focusing on the teachers' perception of their role in class. The role of the teacher in class varies from being an *Authority* to being a *Facilitator*. I defined *Authority* as a teacher who says that he/she is the leader of the teaching process in class; he/she perceives his/her place as the center of the teaching process. *Facilitator* was defined as a teacher who says that his/her role is to guide the students; he/she puts the student in the center of the teaching process. The hierarchy is described in an ascending order. This, together with the model of changing that I have described above, led me to the idea that a teacher could change his/her way of experiencing an animation system, if he/she could change his/her attitudes and his/her feeling of confidence in using the tool, and if he/she would be able to improve his/her capability of using the tool. The following Figure-10 describes a relationship that can be adapted from the model that I have developed in the previous paragraph. I have replaced the attitudes with centrality.

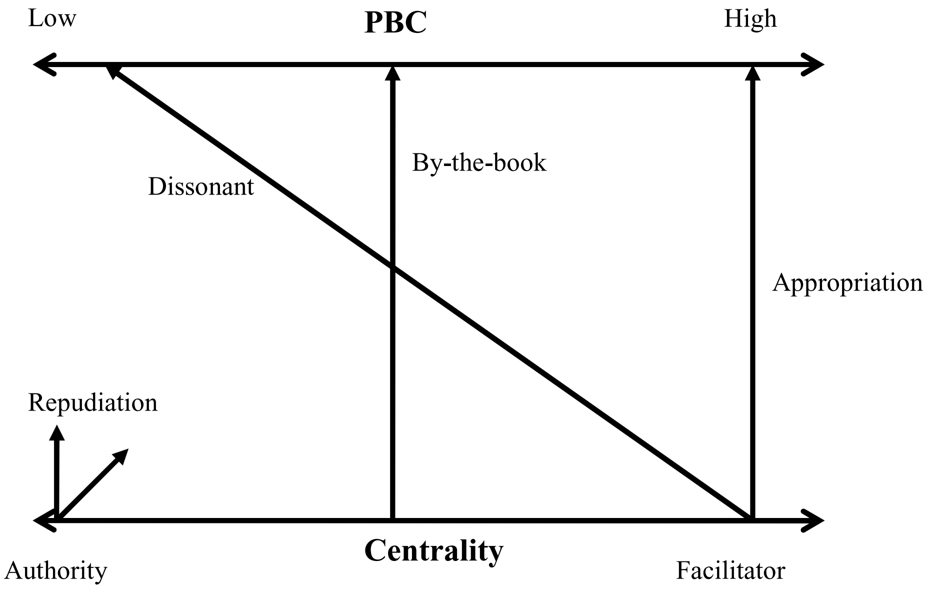

Figure-10 PBC and Centrality

The Authority teachers usually show reluctance to use Jeliot since they feel that they do not need any kind of help. These teachers would feel uncomfortable using Jeliot (see also Trigwell, 2000 and Zibek, 2002). The Facilitators usually accept the use of Jeliot since this engagement facilitates their teaching and helps their students. The more the teacher engages in facilitation and the higher his/her perceived behavior control is, the more he/she will experience Jeliot in the Appropriation category (according to the profiles). The most interesting result is the Dissonant teacher, who—in spite of his/her propensity to facilitate—has his/her pedagogical decision affected by his/her low perceived behavior control. To change him from Dissonant to By-the-book or Appropriation could be achieved by trying to change either his/her attitude towards his/her centrality or his/her perceived behavior control. Further research is needed in order to see if these types of changes will be effective.

6.7 Limitations of the Study

The research population for the phenomenographic phase consisted of four groups of CS teachers (marked A–D). According to the TPB, the size of the population should be at least 80 (Francis, Eccles, et. al, 2004, p. 28); since only 25 teachers responded to my request to fill in the questionnaire, there might be limitations to the validity of my analysis. The eight teachers in group A were observed and underwent the interviews that were the basis of the phenomenographic analysis. Later, six of the group filled in the questionnaire, which was the basis for the TPB analysis. The results were thus based both upon phenomenography and upon TPB. This is how I could relate the behavior found in the TPB analysis to the categories from phenomenography.

7. CONCLUSIONS

In spite of the very encouraging results that research on the benefits that the use of animation systems has on the CS students, many animation systems are “orphans” (Hundhausen, 1997). The literature review in the chapter on the theoretical background deals with — among other subjects —curriculum and its use by teachers. Asking a teacher to use a software tool in his/her classes is asking him to make a change in his/her practice. The literature on the difference between the intended curriculum and the enacted curriculum is large. Developers of animation systems usually give technical instructions on how to install or use the tool, but they rarely give instructions on how to integrate the tool into the intended curriculum. The gap between the intended curriculum and the enacted one, together with the fact that the use of animation systems is not as widespread as I thought it should be, led me to the rationale of my study.

7.1 The Phenomenographic Phase

In order to understand the anomaly of the low use of these software tools in spite of the improvement they bring to students’ understanding of CS topics, I raised the first research question—a qualitative one—that dealt with the qualitatively different ways that teachers experience an animation system in their classes. Since I did not know what to expect as answers to that question, I used the phenomenographic framework and methodology. Phenomenography is a qualitative methodology that is used in order to describe the ways subjects experience a phenomenon. In my case, the subjects were CS teachers and the phenomenon is Jeliot—an animation system that was developed specifically for teaching and learning CS topics by novices.

The phenomenographic analysis yielded four categories. Two of them (Appropriation and By-the-book) describe the experience of using animation in positive terms: the first very enthusiastically and the second less so, but perhaps the attitudes of teachers experiencing animation in this way will become more positive as they gain more experience. Two of the categories (Repudiation and Dissonant) describe negative experiences. These four categories were placed into a hierarchically ordered outcome space that gives a description at the collective level.

7.2 The TPB Phase

During the phenomenographic phase of my study, I found that many teachers made their decisions to use or reject an animation system very close to the time they were exposed to it. This decision depends on the attitudes that the teachers had towards the use of an animation system in their classes. Therefore, I raised the second research question—a quantitative one—that was directed to understanding the reluctance to use an animation system. I decided to complement my study with another methodology (TPB) that connects between attitudes and behavior of individuals. I constructed a methodology that combined both phenomenography and TPB by using the interviews from the phenomenographic phase as the basis of the questionnaire I developed according to the TPB methodology. This phase provided results that dealt with the attitudes that teachers, as individuals, possess towards the use of an animation system as a pedagogical tool.

The results show that—in general—CS teachers have high attitudes and high intentions towards the use of Jeliot. This result is not surprising since CS teachers were trained to use software tools, and in fact they routinely use software tools in their laboratories. Therefore, the low score of the indirect perceived behavior control predictor was a surprise to me. Perceived behavioral control is the extent in which a person feels that he/she can control the behavior, and it has two aspects: (1) how much *control* a person has on the behavior (*control beliefs*), and (2) how confident a person feels about his/her *ability* to behave in a certain way (*influence of control beliefs*). I found that CS teachers feel that they lose control on their students. The teachers have to rely on the laboratory technician, which means that they lose control on installation. Some of the teachers feel that they do not need Jeliot because its explanations jeopardize their authority in the class. The last reason is a paradox, since the explanations are the strength of Jeliot. Teachers are afraid to lose their central role in class; they might be caught making mistakes, since Jeliot is a dynamic system as opposed to PowerPoint presentation which is static. This dynamic attribute makes some of teachers feel uncomfortable with the system.

From this phase, I learned the extreme importance of issues relating to control. It is not enough to develop a beautiful and pedagogical useful tool; issues such as easy installation, training courses and tutorials are of equal importance, because they can increase an educator's feeling of control. Similarly, training courses should not ignore operational or pedagogical difficulties that can arise from the use of a software tool. They should address the changing role of the teacher when using the tool, emphasizing that they remain in control and do not relinquish their central position.

7.3 The Back-to-Phenomenography Phase

The results of the TPB phase were interpreted by returning to the phenomenographic interviews and conducting some re-analysis. I wanted to associate teachers to the profiles I designed. The idea was to predict which teachers might belong to the negative profiles, in order to give them appropriate treatment in a course on Jeliot. The first model I developed showed that a course on an animation system should concentrate on both: how to use the system as well as on the attitudes of the teachers. Changing the attitudes from negative to positive could shift the teachers from being associated to the Repudiation profile to By-the-book or to Appropriation. A similar change could be achieved by addressing the treatment on control problems in order to change the PBC from low to high; the change can shift teachers from being Dissonants to By-the-book or Appropriation.

The second model I developed deals with the profiles as describing the connection between PBC and the way teachers perceive their role in class. Changing the PBC may cause shifting a teacher who was classified as Dissonant to a teacher who can be classified as By-the-book or even as Appropriation.

7.4 The Voice of Reluctance

The concentration on the negative ways of experiencing gives a voice to teachers who do not use Jeliot. Usually, when a tool is being studied, the study is centered on the users, their problems, their success, etc. Since I was bothered by the low use of Jeliot, I decided to study from the negative approach.

The profiles that I found can help developers, especially when writing tutorials and teacher training courses, by indicating the type of reactions that educators are likely to have and the ways to address their anxieties. This is important because tool developers tend to concentrate on improving their systems' technical capabilities, and devote less effort to integrating the systems into the teachers' practices, as well as into the curriculum. My study shows that this integration is very important for the teachers.

Another important conclusion is that if problems of perceived behavior control arise with CS educators, *a fortiori* they will arise with teachers of other subjects. I believe that research on CS educators and tool developers can contribute to the acceptance of educational technology by the further study of this phenomenon and by devising ways to overcome the difficulties.

I attribute the negative experience to two primary causes: First, a pedagogical software tool cannot stand on its own; rather, it must be integrated into the curriculum through other learning materials such as the textbook. Tool developers tend to invest most of their efforts in improving the technical capabilities of their software and leave the integration to individual teachers. This may be expecting too much and is probably not the best way to go about it, because it is the developer who has the best feel for what the tool can accomplish.

Second, to the extent that a software tool is intended for independent use by students as opposed to demonstrations during frontal instruction by the teacher, the issue of the centrality of the teacher must be taken into account. Centrality appears to be an issue both for experienced and highly confident teachers, as well as for those with little experience and low self confidence. Addressing this issue may be connected with the previous one: to the extent that a software tool is integrated with other learning materials, it may appear less threatening.

7.5 The Integrated Methodology

This study described how I found, adopted and adapted research methodologies as needs appeared during the progress of the research. I showed how my methodology started from a purely phenomenographic one, and was then supplemented by a totally different methodology that was needed to pursue a surprising result that came from the initial analysis. In the later stages of the research, the circle was closed when the TPB results were interpreted using the categories from phenomenography. I even returned to do a re-analysis using phenomenography in order to solve an anomaly that resulted from the TPB analysis.

8. FUTURE RESEARCH

The research reported in this thesis pointed to or resulted in several new research directions that could be pursued in the future.

The integrated methodology (Section 3.3) could be used to study teachers from other disciplines who use educational technology. This kind of study would help understand the teachers' attitudes towards the use of educational technology better. I believe that each discipline possess its own typical problems. Understanding the attitudes will help developers of educational technology tools adjust the tools to the real needs of the teachers, specifically to improve the teachers' perceptions of the role in their classrooms while using educational technology tools.

Furthermore, as I discussed in Subsection 6.6, the relationship between perceived behavior control (PBC) and Attitudes can be used in order to shift teachers from lower ways of experiencing to higher ones. It would be meaningful to design interventions (both technical and pedagogical) to address both PBC and attitudes of the teachers, thus reducing the anxiety and dissonance that they exhibit when encountering educational software technology. Social psychologists believe that changing attitudes is easier than changing behavior, but changing the attitudes of people is the first step towards changing behavior.

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10. PUBLICATIONS DERIVED FROM THE DOCTORAL RESEARCH

Paper in refereed journal

1. Ben-Bassat Levy, R., & Ben-Ari, M. (2009). Adapting and merging methodologies in doctoral research. *Computer Science Education*, *19*(2), 51-67.

Papers in refereed conferences

2. Ben-Bassat Levy, R., & Ben-Ari, M. (2009). A survey of research on the Jeliot program animation system. In Y. Eshet-Alkalai, A. Caspi, S. Eden, N. Geri, & Y. Yair (Eds.), *Proceedings of the Chais Conference on Instructional Technologies Research: Learning in the technological era* (pp. 41–47). Raanana, Israel: Open University.

3. Ben-Bassat Levy, R., & Ben-Ari, M. (2008). Perceived behavior control and its influence on the adoption of software Tools. *Proceedings of the 13th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education, Madrid, Spain,* 169-173.

4. Ben-Bassat Levy, R., & Ben-Ari, M. (2007). We work so hard and they don't use it: acceptance of software tools by teachers. *Proceedings of the 12th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education, Dundee, Scotland*, *UK*, 246-250.

11. DECLARATION

This Thesis summarizes my independent efforts.

APPENDIX A

Interview questions to teachers using Jeliot

I am conducting a study of computer science teachers in Israel. I am interested in the reasons why computer science teachers do not choose to use an animation system in their classes. I would appreciate your responses to some questions about this. There are no right or wrong answers. Please tell me what you really think.

You have just studied about the Jeliot which is a program animation system: how to install it, how to work with it and how to use it as a pedagogical tool in class.

a. What do you believe are the ***advantages*** of using an animation system as a pedagogical tool in class?

b. What do you believe are the ***disadvantages*** of using an animation system as a pedagogical tool in class?

c. Is there anything else you associate with using an animation system as a pedagogical tool in class?

d. What factors or circumstances would enable you to use an animation system as a pedagogical tool in class?

e. What factors or circumstances would make it difficult for you to use an animation system as a pedagogical tool in class?

f. Are there any other issues that come to mind when you think about using an animation system as a pedagogical tool in class?

g. How did you use the animation in class? Did you have any pedagogical instructions to do so? Can you recommend a way to use an animation in classes?

h. What does it mean "teaching with an animation system?" How do you see the role of a teacher who uses an animation system? Have you had to change any of your teaching techniques?

i. Can you describe the preparation of a lesson that uses Jeliot?

j. Can you describe your best lesson using Jeliot?

k. Can you recommend when to use Jeliot?

l. Can you recommend when *not* to use Jeliot?

m. The students understood before they had an animation system – what do you think is the animation system place in the curriculum?

Thank you

APPENDIX B

The final questionnaire

1. When are you going to use the animation system?
2. When will you avoid using the animation system?
3. Does your school have facilities appropriate to the use of an animation system?
4. How would you feel if you were obliged to teach with an animation system?
5. How do you find the animation system? Does it cause you any difficulties?
6. Did the course change your attitudes towards the use of an animation system?
7. How do you feel about teaching the use of an animation system in a Java course?
8. What do you think about giving pedagogical knowledge in a course that is intended to teach content?
9. Comment about the course on Jeliot.

Thank you

APPENDIX C

Observation of a teacher using Jeliot

and the questions asked

1. The subject chosen by the teacher is: ________________________________.

2. Why have you chosen the subject?

____.

____.

3. The animation method chosen by the teacher (Step by step, Run automatically, Run with verbal explanations, Repetitions, Exploratory mode):

Description:

Step by step: ____.

Run automatically: ____.

Run with verbal explanations: _______________________________________.

Repetitions: ____.

Exploratory mode: ____.

4. Problems that the teacher said he faced while preparing the lesson:

____.

5. Advantages of the animation system as a pedagogical tool as expressed by the teachers:

____.

____.

6. Special notes on the performance of the teacher:

____.

____.

____.

____.

____.

7. Other participants' reactions towards the lesson:

____.

____.

APPENDIX D

Personal details questionnaire

Name: ______________________________ .

Personal address: ______________________________ .

Tel: ______________________________ .

Mobile phone: ______________________________ .

Email: ______________________________ .

School: ______________________________ .

School address: ______________________________ .

School phone: ______________________________ .

Subject of study: ______________________________ .

University degree: (None, BA, MA, Msc, PhD)

Teaching certificate (y/n):

Teaching classes: junior-high / high school

Teaching subjects:
1. ______________________________ .
2. ______________________________ .
3. ______________________________ .
4. ______________________________ .

Years of experience: ______________________________ .

Do you know Java? (y/n)

Do you know what an animation system is? (y/n)

If yes please describe it: ____ .

____ .

____ .

____ .

____ .

Thank you

APPENDIX E

The attitudes questionnaire

I am conducting a study of computer science teachers in Israel. I am interested in your opinions about computer science teachers. I would appreciate your responses to some questions about this. There are no right answers or wrong ones. Please tell me what you really think.

Ronit Ben-Bassat Levy
Departmant of Science Teaching,
Weizmann Institute of Science

SECTION 1

About your *BACKGROUND*

A. How long have you been a teacher? _______________Years
B. Your degree is: B.sc. in Computers Science / Other: _______________
C. Do you have a teaching certificate? Yes / No
D. Are you Male / Female?
E. Do you have previous experience in using an animation system? Yes / No
F. If you want to you can write your name here: ____________________
G. Date: ____/ _____/ _____

SECTION 2

Using an animation system as a pedagogical tool in class

1	If I am using an animation system in class, I feel that I am doing something positive for the students.	Likely	1	2	3	4	5	6	7	Unlikely
2	The use of animation system will cause my student confusion, since they are very weak students.	Strongly disagree	1	2	3	4	5	6	7	Strongly agree
3	If I use an animation system in class it would be easier to understand some difficult topics that I know that students face while studying concepts in CS.	Strongly disagree	1	2	3	4	5	6	7	Strongly agree
4	The animation system is not needed since I am an experienced teacher.	Strongly disagree	1	2	3	4	5	6	7	Strongly agree
5	If I use an animation system then I feel that I am not in control of my students' understanding.	Unlikely	1	2	3	4	5	6	7	Likely
6	The use of an animation system in class saves time.	Strongly disagree	1	2	3	4	5	6	7	Strongly agree
7	The technician in the laboratory is not competent.	Unlikely	1	2	3	4	5	6	7	Likely
8	The laboratory in my school does not have the desired equipment to use this animation system (missing a projector or does not have software to show on all computers).	Unlikely	1	2	3	4	5	6	7	Likely
9	My students are strong therefore I feel that they are going to be bored.	Unlikely	1	2	3	4	5	6	7	Likely
10	The animation system is not a part of the curriculum.	Unlikely	1	2	3	4	5	6	7	Likely
11	The animation system provides explanations that are not needed since I am in class.	Unlikely	1	2	3	4	5	6	7	Likely
12	When I teach I like to wander among the students.	Unlikely	1	2	3	4	5	6	7	Likely

13	Doing something positive for the students is:	Extremely undesirable	1 2 3 4 5 6 7	Extremely desirable
14	Causing confusion for the students is:	Extremely undesirable	1 2 3 4 5 6 7	Extremely desirable
15	Detecting understanding problems is:	Extremely undesirable	1 2 3 4 5 6 7	Extremely desirable
16	Harming my role in class is:	Extremely undesirable	1 2 3 4 5 6 7	Extremely desirable
17	Losing control on my students is:	Extremely undesirable	1 2 3 4 5 6 7	Extremely desirable
18	Saving time is:	Extremely undesirable	1 2 3 4 5 6 7	Extremely desirable
19	Developers and the training teacher think that I	should not	1 2 3 4 5 6 7 use an animation system in class.	should
20	The school management would	disapprove	1 2 3 4 5 6 7 of my using an animation system in my class.	approve
21	My colleagues	do not	1 2 3 4 5 6 7 use an animation system in class.	do
22	I am confident that I could use an animation system in class if I want to.	Strongly disagree	1 2 3 4 5 6 7	Strongly agree
23	For me to use an animation system in class is:	easy	1 2 3 4 5 6 7	difficult
24	The decision to use an animation system in class is beyond my control.	Strongly disagree	1 2 3 4 5 6 7	Strongly agree
25	When I have problems with the laboratory, I am	less likely	1 2 3 4 5 6 7 to use an animation system in my class.	more likely
26	Incapable technician makes it much	more difficult	1 2 3 4 5 6 7 to install the animation system.	easier
27	When students feel bored while using an animation system, I am	less likely	1 2 3 4 5 6 7 to use it.	more likely

28	Teaching with something that is not in the curriculum, makes it	less likely	1 2 3 4 5 6 7 to use it.	more likely
29	When the explanations provided by the animation system take my place, I am	less likely	1 2 3 4 5 6 7 to use it.	more likely
30	When I have to stand near the board or the computer because of the animation system, I am	less likely	1 2 3 4 5 6 7 to use it.	more likely
31	Most people who are important to me think that	I should	1 2 3 4 5 6 7 use an animation system in class.	I should not
32	It is expected of me that I use an animation system in class.	Strongly disagree	1 2 3 4 5 6 7	Strongly agree
33	I feel social pressure to use an animation system in class.	Strongly disagree	1 2 3 4 5 6 7	Strongly agree
34	I *expect* to use animation for explanations.	Strongly disagree	1 2 3 4 5 6 7	Strongly agree
35	The approval of my teaching by the developers and the training teacher is important to me.	No at all	1 2 3 4 5 6 7	Very much
36	I *want* to use animation for explanations.	Strongly disagree	1 2 3 4 5 6 7	Strongly agree
37	What the school management thinks I should do matters to me.	No at all	1 2 3 4 5 6 7	Very much
38	Doing what my colleagues do is important to me.	No at all	1 2 3 4 5 6 7	Very much
39	I *intend* to use animation for explanations.	Strongly disagree	1 2 3 4 5 6 7	Strongly agree

Thank you for your cooperation

APPENDIX F

Scoring key for questionnaire

Question number	Question number in short questionnaire	Response format	Items requiring reverse coding	Items requiring internal consistency analysis	Items requiring multiplication not in short questionnaire	Construct measured
1 to 6	1 to 6	1 to 7	3		1*13 , 2*14 , 3*15 , 4*16 , 5*17 , 6*18	behavioral beliefs (BB)
7 to 12	7 to 12	1 to 7	8		7*26 , 8*25 , 9*27 , 10*28, 11*29, 12*30	control beliefs (CB)
13 to 18	13	1 to 7			1*13 , 2*14 , 3*15 , 4*16 , 5*17 , 6*18	behavioral beliefs outcome evaluation (BBOE)
19 to 21	14 to 15	1 to 7			19*35 , 20*37 , 21*38	normative beliefs (NB)
22 to 24	16 to 18	1 to 7	24	22 to 24 after recoding		perceived behavioral control (PBC)
25 to 30	19 to 24	1 to 7	29		7*26 , 8*25 , 9*27 , 10*28, 11*29, 12*30	Outcome of control beliefs (power) (OCB)
31 to 33	--	1 to 7		31 to 33 after recoding		subjective norms (NS)
34,36,39	25 to 27	1 to 7		34,36,39		intentions
35,37,38		1 to 7	35,37,38		19*35 , 20*37 , 21*38	Normative beliefs motivation to comply (NSMC)