Perspectives on developing and assessing professional values in computing

Ursula Fuller
Computing Laboratory
University of Kent
Canterbury CT2 7LG UK
u.d.fuller@kent.ac.uk

Bob Keim
Computing Laboratory
University of Kent
Canterbury CT2 7LG UK
r.g.keim@kent.ac.uk

Diana Fitch
Careers Service
University of Southampton
Southampton SO17 1BJ UK
d.j.fitch@soton.ac.uk

Joyce Currie Little
Towson University
Towson, MD 21252 USA,
jclittle@towson.edu

Charles Riedesel
University of Nebraska
Lincoln NE, USA
riedesel@cse.unl.edu

Su White
ECS
University of Southampton
Southampton SO17 1BJ UK
saw@ ecs.soton.ac.uk

ABSTRACT
This paper discusses how to ensure that students attain professional values important to the workplace by integrating them into computing curricula. It describes a survey of the attitudes of students, faculty and professionals in computing towards the teaching and assessment of such values. The results show that these groups share a set of professional values, though students are less convinced of their importance in the work environment. There is broad consensus on the specific behaviors and attitudes reflective of these values to be developed in the curriculum. The groups differed in their opinions of whether these attitudes and behaviors could be workably assessed.

Categories and Subject Descriptors
K.3.2 [**Computers and Education**]: Computer and Information Sciences Education – *computer science education, cu*rri*culum*

General Terms
Human Factors

Keywords
Professional issues, professional values, computer science education, curriculum, assessment

1. INTRODUCTION: WHY THIS MATTERS
Computing is an academic discipline that 'combines the ethos of the scholar with that of the professional' [31]. Computing degrees are expected to introduce students to professional practice, inducting them into the shared values and attitudes of the community of computing professionals, as well as educating them in subject-specific knowledge and understanding, together with technical and transferable skills.

This working group report addresses the academic area of teaching professional values in computing, part of the broader scheme of "professionalism". Professional values are the underpinning values that a professional workforce in computing needs to care about and work toward, in order to responsibly carry out their work. The job descriptions of computing professionals are becoming increasingly complex. There are three stakeholders that are important to the professionalization of computing: industry, government, and academia, representing the respective and overlapping motivations of work, society and education.

We address the need for our curricula to develop and measure professional values, to ensure that students recognize, appreciate, and attain professional values important to the workplace, society, and the well-being of the world. The challenge of this considerable task, to all of us, as educators of the computing workforce, needs to be recognized and respected.

Students studying computing fields often have strong career orientation and have come to study computing with the intent of getting a graduate job in computing. It is the responsibility of academics to acknowledge these aspirations in their teaching and assessment. For many, computing is a vocational choice rather than something to be pursued purely from a love of subject.

Explicit teaching and assessment of professional values and behaviors may encourage convergence between the academic and employment goals and environments and create better work outcomes for more graduates.

To achieve these goals, our students need to evolve clear ideas of what it means to be a computing professional during the course of their studies and they need to experience situations where the impact of these values becomes apparent. We hope that through assessment of these attributes, students will begin to value them, recognize them in themselves and be able to communicate them to others. The benefits should be more employable students, and graduates more aligned to professional values and professional working practice and therefore more successful in achieving their post-graduation goals.

1.1 External curriculum/benchmark recommendations

Curriculum is strengthened by incorporating professional values from the very start. Stakeholders of every sort now make use of benchmarking statements to establish and define expectations of curriculum content, educational processes and assessment practices. Some benchmarks are concerned with input standards as well as output standards, and many express expectations of hours of study, and incorporate expected levels of attainment. The most influential body in the benchmarking arena varies from country to country, reflecting the relative autonomy of the educational system and the historic precedents for authority in professional education, training and development.

In the UK, the government initiated Quality Assurance Agency has held sway alongside the Engineering Council (a professional body representing a range of established bodies across the engineering disciplines). In the US it is probably the ACM which has had the biggest benchmarking impact.

The Bologna agreement can be seen as the consequence of a European desire for greater trans-national employment mobility, and greater transparency across different long established higher educational institutions. It has been a catalyst for innovation in the computing curriculum in many European universities. Preparing for Bologna compliance and the prospect of Europe-wide standards for graduation, accreditation and certification in informatics have been the topic of discussion of conversation in recent years in various forums, notably a series of events organized as Informatics Education Europe, and the Informatics Europe, European Computer Science Summit. Consequences include the introduction of broader areas of study, utilizing a wider range of assessment types and achieving better alignment between curriculum content and assessment processes [19].

In the UK, a national regime of quality inspections was initiated for comparability and transparency in teaching practice. In the USA work by IEEE and ACM have produced professional benchmarks covering similar areas but motivated by slightly different circumstances. However it seems clear that work still needs to be done to quantify the extent of professional education across our respective subject areas.

In all cases benchmarks are established and defined the knowledge and expertise of a panel of authors drawn from appropriate representative educational, industrial and professional organizations. The need to develop professional values is recognized in Computing Curricula 2001 (CC2001), drawn up by the IEEE and ACM [1] and the UK Computing Subject Benchmark [31]. CC2001 specifies that graduates should "Be guided by the social, professional, and ethical issues involved in the use of computer technology." In commenting on the need to include Professional Practice in the Curriculum, the Joint Task Force says

> Accreditation bodies, however, usually require not only that students *acquire* these skills—either through general education requirements or through courses required specifically for computer science—but also that students *apply* these skills in their later courses [1].

It commends the threshold and modal (average) standards of performance for computing graduates specified in the UK's Computing subject benchmark [31]. This states that, at threshold level, graduating students will be able to

> identify appropriate practices within a professional and ethical framework and understand the need for continuing professional development

whereas the average graduating student will be able to

> apply appropriate practices within a professional and ethical framework and identify mechanisms for continuing professional development and life long learning.

This clearly assumes that differing degrees of commitment to professional practice and life-long learning can be discerned; in other words, it implies assessment in the affective domain.

CC2001 discusses how professional practice can be assessed:

> The assessment process should encourage students to employ good technical practice and high standards of integrity. It should discourage students from attempting to complete work without giving themselves enough time or in a haphazard manner, such as starting and barely completing work the night before an assignment is due.

But this document gives no guidance on how to measure professional practice values and attitudes. This is reflected in the learning outcomes for computing programs and courses and in the assessment methods we use. This tension between what is in the curriculum and what we assess will continue to increase in importance as the requirement to emphasize professionalization in the CS curriculum develops further.

1.2 Our approach

Definitions and explanations of professional values encompass competencies such as teamwork and attributes such as integrity. We could assume that whilst academics would be comfortable with the desirability and possibility of teaching and assessing teamwork, they would be less likely to consider more difficult attributes such as integrity.

How true would such an assumption be? Are academic professionals comfortable with the idea of instilling professional values in their students, and would their attitudes be similar to those of computing professionals working in industry? What would the students feel about being *exposed to such issues* and being *assessed on them*? To further explore these issues, we recognized the need to clarify the terms 'professionalism' and 'professional values'. What had been done previously on these matters? Could further insight be provided by additional theoretical exploration?

Our purposes were therefore threefold,

- To determine something about the attitudes of key groups to the assessment of the professional values of the computing professions,
- To more clearly ascertain what key groups such as professional associations, certifying bodies, academic institutions and businesses, had to say about the matter
- To clarify the notion of 'professionalism' and 'professional values' particularly as they applied to computing.

While a lot has been written about ethics in computing and there is a well-established bi-annual ETHICOMP survey on ethical topics [30], we were unable to find empirical data on the perceptions of computing professionals, faculty and students on the importance of professional values in computing degrees. We therefore decided to collect data to test a number of hypotheses based on earlier work.

1.3 Survey Hypotheses

Ethical and professional values are held both individually and collectively. These values should guide the behavior of computing professionals at all times in their professional activity, so it is essential that they are internalized by each individual. They must be linked to the person's wider ethical and personal values, and so the development of professional values has to be an individual process. On the other hand, professionals need the support of the collectivity to legitimize their choice of behavior in difficult circumstances and the collectivity needs to regulate the professional behavior of its members in order to uphold its reputation. There is evidence that members of professional ethical panels typically have highly divergent ethical frameworks and yet they have a high degree of accord when making decisions on real cases [23]. We therefore hypothesized that

H1. There is considerable agreement about a large range of professional values amongst computing professionals.

We would expect students, as professionals in the making, to be some way toward sharing the values of established computing professionals. We therefore hypothesized that

H2. There is considerable agreement about a large range of professional values amongst students.

H3. Students do not mind being evaluated on their practice of professional values.

By no means all teachers of computer science consider themselves to be computing professionals. For some this is because they come from another discipline, such as mathematics or business. Others see themselves as scientists rather than practitioners. This may mean that their personal professional values are legitimately not closely aligned to those of a computing professional. Nevertheless we hypothesized that there is a shared core and that

H4. There is considerable agreement about a large range of professional values amongst teachers of computing.

H5. There are areas of professional values that teachers are prepared to recognize and inculcate.

In addition, although we did not assume that students, faculty and professionals would have an identical set of shared values, we hypothesized that

H6. There is a consensus that it is appropriate to evaluate students' ethical and professional values.

1.4 Building the Questionnaire

The informal ITiCSE'99 survey of professional values provided us with an ordered list of desired characteristics of computing professionals [see the first column of Table 1]. We saw this as a starting point for exploring the extent to which these characteristics were regarded as desirable, the extent to which they might be taught and the extent to which they might be assessed. With this goal in mind, it was clear that we needed to explore a matrix of values and ask our respondents whether they felt each of these values were worthwhile to teach, worthwhile to assess and worthwhile in employment.

In trialing an initial survey directly based on Little et al. [26] and Maister [27], we discovered some confounding ambiguities; for example, the item 'Does what it takes to get the job done' was identified as including anything from diligent application focused on crucial tasks to unscrupulous manipulation. Clearly, responses would be highly dependent on the varying interpretations of individual respondents. A second issue identified was that some mentioned characteristics were compound; for example 'Is honest, trustworthy and loyal' included both honesty and loyalty which in some contexts would be disparate. In addition, while some characteristics seem to designate stable attitudes, others seemed not to be characteristics but behavior patterns. The outcome was the split into attitudes and behaviors based on the original list of values shown in the second and third columns of Table 1.

We used the items listed in the center and right columns of Table 1 in our surveys. A separate and parallel survey was developed for students, for faculty and professionals. A part of each survey explored how important these characteristics were thought to be in working life, whether they should be inculcated through the curriculum, whether it was useful to determine whether students demonstrated them through their behavior and whether they could workably be assessed. A compressed version of the questionnaire used for faculty members is included as Appendix A, annotated to show how it differs from that for professionals and students.

Members of the working group surveyed computing professionals with whom they had contact, either through employers or the local branch of the professional body. This resulted in 59 responses from computing professionals, 50 in the UK and 9 in the USA. They predominantly work for large companies but there are also representatives of SMEs and public sector employers. Because of the small numbers involved, we did not collect demographic information on the computing professionals. Working group members also surveyed faculty in their home institutions and a number of responses were also obtained from ITiCSE attendees. In all 38 faculty completed questionnaires. Finally, working group members in the UK surveyed students in their home institutions, obtaining 134 responses from students at all levels of study from freshmen to masters students. The data collection had to be carried out after the end of the teaching year in the US, so it was not possible to collect data from any American students. While none of these were random samples, we have no reason to believe that the respondents are atypical of their underlying populations, though it is possible that the computing professionals are more interested in professional issues than the norm for this population since they were mostly contacted through professional organizations.

Table 1 Professional values as attitudes and behaviors

Desirable characteristics of computing professionals provided in Little et al. [26], ordered beginning with most desirable.	**Corresponding attitudes explored in our surveys**	**Corresponding behaviors explored in our surveys**
Shows a personal commitment to quality	Personal commitment to quality	
Is honest, trustworthy and loyal	Honesty and trustworthiness	
	Loyalty to organizations of which one is a part	
Does whatever it takes to get the job done	Being willing to put in the extra effort needed to successfully complete necessary tasks	Puts in the extra effort needed to successfully complete necessary tasks
Becomes a team player	A willingness to listen to those one works with	
Listens to the needs of those they serve		Attends to the needs and expectations of users, clients, customers or bosses (or the equivalent of these in academic settings)
Is open to constructive critiques on how to improve	An openness to constructive critiques on how to improve	
Anticipates and does not wait to be told what to do		Anticipates and does not wait to be told what to do
Understands and thinks like those they serve	A willingness to attempt to understand and think like the users, customers or consumers of the products being developed	
Takes pride in work	Taking pride in work	
Reaches out for responsibility		Reaches out for responsibility
Gets involved and goes beyond their assigned job		Gets involved and goes beyond their assigned tasks
Meets client/user expectations	An eagerness to meet the expectations of users, clients, customers or bosses (or the equivalent of these in academic settings)	Meets client/user expectations
Thinks differently/creatively		Thinks creatively

2. PROFESSIONALISM AND PROFESSIONAL VALUES

This section presents theoretical concepts of professionalism and professional values, followed by survey results that show the extent to which our samples of computing professionals, faculty and students share in these values.

2.1 The Growth of Emphasis on Professions and Professional Values

The professions have been seen as having a significant effect upon human life and well-being, but for the early professions of law, medicine and the ministry, such impact was limited to the few individuals with whom professionals had direct contact. With technological changes risks as well as benefits quickly spread. As areas such as architecture and engineering became professionalized, the scope for impact became wide-spread; one individual's professional activities could affect people with whom she or he would never have contact. For those professions, and for the computing professions, doing one's job well means having a positive impact on human well-being and advancement; failing to do it well will result in the opposite [39].

With the Internet and worldwide computing, risks of invasive products and malware reach everywhere. In addition, the workforce itself has become worldwide as off-shoring and outsourcing have made evident. Today's computing workforce is international and the needs for worldwide professional values in the computing workforce need to be increasing recognized.

While professionals are sometimes in a position to choose courses of action for which they can be sufficiently guided by subject knowledge, they may often be in the position of having to make choices in complex situations where the consequences of their actions are unforeseen and unforeseeable. As society becomes more dependent on computerization, more instances of these problems and risks have even life-threatening consequences. Examples of some of these cases are well-documented in the Risks Forum, a project of the ACM, available online [29, 16].

2.2 The nature of professionalism

The prior work on the incorporation of professionalism in computing into academic settings was described by an ITiCSE 1999 Working Group [14]. This used the sociological definition of a profession from Benveniste [5], which requires these six characteristics:

1. Application of skills based on special knowledge
2. Requirements for advanced education and training
3. Formal testing of competence and control on admission
4. Existence of a professional association
5. Existence of a code of conduct or ethics
6. Existence of an accepted commitment or calling or sense of responsibility for serving the public.

The sociological model of a professional is incremental and cyclical, starting with the development of formal skills and specialized knowledge for the work; then requiring evidence of such development, such as through formal testing; receiving an endorsement, often in the form of a license, to engage in the practice, and ascribing to a professional code of ethics or code of conduct; maintaining and updating skills and knowledge on some schedule; and periodically reassessing preparedness to practice, reentering the cycle with the new material.

Another way often used to define professionalism is to enumerate the characteristics it requires, sometimes referred to as values. Maister [27] supplied a list of characteristics including these: taking pride in the work; showing a commitment to quality; ability to function well in a team; and being honest and trustworthy.

Early concern for the societal impact of computing on the general public emphasized not the sociological aspects but more the behavioral attributes – whether practitioners were able to perform, with evidence of professional values appropriate for the technical and social standards expected. In 1975, in his article "Professionalism in the Computing Field", Aaron Finerman [10, p. 4] defined seven characteristics, including:

- "The professional has a high degree of individual responsibility, a willingness to take initiatives, and a sense of obligation to identify client (and employer) needs as well as client (and employer) wants."
- "The professional has a sense of responsibility for the quality of the work performed, a high self-imposed standard of workmanship to maintain that quality, and joy and pride in performing that work."
- "The professional is aware of the effects that services performed have on society and has a sense of responsibility for serving the public good."
- "The professional has an understanding of the interaction and relationship between facts and values (or technology and values)."

2.3 The Industrial Workforce

Increasing concern in the US for the computer industry workforce to become more professional led to the creation of the Institute for the Certification of Computer Professionals, later changed to become the Institute for the Certification of Computing Professionals (ICCP). Founding organizations included the Association for Computing Machinery (ACM), the Institute for Electrical and Electronic Engineers (IEEE)-Computer Society, and the Data Products Management Association (DPMA), who brought their existing certification examinations into the new organization. The goal of the new organization was to work with all professional associations in computing to coordinate the development of, and the recognition of certification programs to assist in the professionalization of the discipline. The ICCP offers several credentials, including the Certified Computing Professional (CCP), for individuals to show their attainments, in several specialties. Examinations for these credentials are now offered around the world.

As technological advance increased the number of specializations expanded, and as the number of computer-related corporations increased, hardware and software became more specialized. This led to the rise of vendor-specific education, vendor training, and vendor certifications. Many of these certifications are offered directly by the corporations, which include Microsoft, Novell, Sun Microsystems, and Oracle, while others are offered through vendor-owned organizations such as CompTia [8].

2.4 Codes of Conduct

Engineering and computing professionals face complex sets of problems involving managing not only things but also personal relationships, whether within a team, or with individuals as clients, customers or agents. Documentation of the expectations of their professional values is therefore important in the workplace. Typically such documents take the form of codes of ethics, codes of conduct, or codes of professional practice, one of Benveniste's six requirements of a profession [5].

Codes of conduct both make the professional worker aware of what is expected of them and give them some assurance that they will better know how to function in their job, for example orienting new workers to the culture of their workplace. Corporations adopt these codes, as do professional membership organizations. The strongest penalty for violation in this case is typically dismissal from membership.

A typical "code of ethics" might include such items as:

- avoid hurting others
- strive to achieve high quality in the work
- do not discriminate
- honor property rights
- be honest
- be trustworthy
- respect privacy
- honor confidentiality
- acquire and maintain professional competence
- know and respect laws pertaining to the professional work

Additional items relating to a specific type of work may be included: the code of ethics for software engineering gives specific requirements to ensure that products meet the highest professional standards possible, including, for example, investigation of risks inherent in software development [40].

2.5 Survey Results on Shared Professional Values

We had three hypotheses about shared professional values:

H1. There is considerable agreement about a large range of professional values amongst computing professionals;

H2. There is considerable agreement about a large range of professional values amongst students;

H4. There is considerable agreement about a large range of professional values amongst teachers of computing.

In order to test these, our surveys used a Likert scale to measure agreement or disagreement with the statement "**There is an**

important shared set of values that underlies the profession of computing" (referred to below as the shared values question). We also asked respondents to agree, disagree or neither agree nor disagree for each of the attitudes and behaviors in Table 1 that "**This attitude/behavior will be of value during one's professional life**"[1] (referred to below as useful attitudes and behaviors).

Table 2 and Figure 1 present the responses to the shared values statement, showing strong agreement with H1 – H3 and that

- The preponderance of all three groups agree with this proposition and there is general agreement between the groups. A Kruskal-Wallis test gives an asymptotic significance of 0.307 for differences between the means and one-way ANOVA reveals that practically all the variance is within groups.
- Very few professionals disagree, though, as previously noted, our sample of professionals may be biased in this direction since most were recruited through activities in professional organizations.
- The group most likely to disagree is faculty.

Table 2 "There is an important shared set of values that underlies the profession of computing" (% within type of respondent)

	N	Agree strongly	Agree to some extent	Disagree to some extent	Disagree strongly
Students	132	23	58	16	4
Faculty	38	26	47	24	3
Profes-sionals	57	28	60	9	4
All	227	25	56	15	4

Further analysis of the views of professionals and faculty showed very little difference between the US and UK respondents.

Table 3 shows the percentages agreeing with the value of each of the useful attitudes and behaviors. We have ranked the responses of each group of respondents according to their strength of consensus with it. This can be interpreted as the strength of consensus that this value is important. The value for students on willingness to listen to those one works with is missing because we inadvertently failed to include this in the student questionnaire.

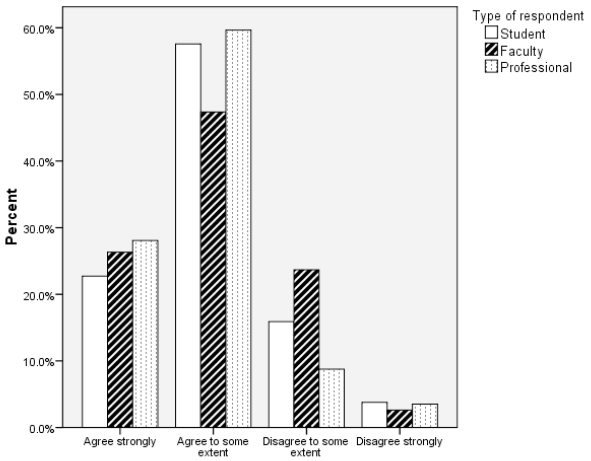

Figure 1 There is an important set of shared values that underlies the profession of computing

It is immediately obvious from Table 3 that loyalty is not on a par with the other professional values. Since the publication of the 1999 Working Group report there have been a number of major corporate scandals, such as Enron, and whistle blowing incidents which we suggest may have changed society's understanding of the value of unconditional loyalty as an appropriate value. This is reflected throughout our survey results, with low support for it as a useful professional value and 13% of respondents actively disagreeing that it is a valuable attribute to have. All the other professional values we identified above receive strong active support. The proportion disagreeing with them is less than 5% in every case, with the sole exception of *Anticipates and does not wait to be told what to do,* which is rejected by 7% of students. Not a single respondent actively disagreed with *Willingness to listen to those one works with* as an attitude of value in professional life.

These results support H1, H2 and H4, that there is considerable agreement on a range of values within each group, but the three groups differ in the relative importance that they give to them. It is interesting that the average level of agreement is effectively the same for faculty and for computing professionals, even though faculty were more likely to disagree that there is a shared set of values. It is also noteworthy that students are less convinced than professionals and faculty that these values will be of use in their professional life. In addition, students set less value on behaviors than on attitudes, whereas professionals and faculty give them the same level of support.

Kruskal-Wallis tests show that the differences between the mean level of agreement with the values in the three groups of respondents are statistically significant at the 5% level for: personal commitment to quality; honesty and trustworthiness; openness to critique; anticipating and not waiting to be told; reaching out for responsibility; getting involved and going beyond the assigned job; meeting client/user expectations, listening to the needs of those to whom they provide services; and putting in the extra effort needed to successfully complete necessary tasks.

[1] Note that there were slight variations of wording in this and some other questions. These are documented in Appendix A.

Table 3 "This attitude will be of value during one's professional life" (% agreeing)

Useful attitudes	Students		Faculty		Professionals	
N=231	%	Rank	%	Rank	%	Rank
A personal commitment to quality	76	1=	92	1=	87	2
A willingness to attempt to understand and think like the users, customers or consumers of the products they are developing	76	1=	84	6=	89	1
Taking pride in work	74	3	92	1=	82	8
Being willing to put in the extra effort needed to successfully complete necessary tasks	74	4	90	3=	83	5=
Eagerness to meet the expectations of users, clients, customers or bosses	73	5	76	8	84	7
Openness to constructive critiques on how to improve	70	6	90	3=	83	5=
Honesty and trustworthiness	68	7	84	6=	86	3=
Loyalty to organizations of which one is part	50	8	47	9	58	9
Willingness to listen to those one works with	NA		90	3=	86	3=
Average for all attitudes	70		83		82	
Average excluding loyalty	78		86		83	

Table 4 "This behavior will be of value in one's professional life" (% agreeing)

Useful behaviors	Students		Faculty		Professionals	
N=231	%	Rank	%	Rank	%	Rank
Thinks creatively	72	1	84	2=	80	4=
Puts in the extra effort needed to successfully complete necessary tasks	69	2	90	1	80	4=
Meets client/user expectations	66	3=	84	2=	84	1=
Listens to the needs of those to whom they provide services	66	3=	84	2=	84	1=
Gets involved and goes beyond their assigned job	61	5	74	6	79	6=
Anticipates and does not wait to be told what to do	60	6	82	5	82	3
Reaches out for responsibility	60	7	71	7	79	7
Average for all behaviors	65		81		81	

All three groups place great importance on personal commitment to quality but professionals rank the behavior of meeting client/user expectations significantly higher than students, and students and faculty rate taking pride in their work significantly higher than professionals. Students' low ranking of honesty and trustworthiness might be considered a matter for concern.

3. PROFESSIONAL FORMATION IN COMPUTING

This section explores the ways in which initial professional development (IPE) and Continuing Professional Development (CPD) are organized between Higher Education, professional training providers and professional bodies. It then presents the results of our survey on attitudes to the inculcation of professional values into computing degrees.

3.1 Models for the Provision of IPE and CPD

Professional education and development activities are typically initiated after the end of compulsory education, but also include some that are begun after job experience. A further complexity is that in some European education systems, compulsory education can incorporate technical education.

Immediately after compulsory education:

- Apprenticeship (a practical foundation but frequently incorporating training courses and professional/qualifying exams)

During degree studies or degree level activity undertaken in tandem with professional employment:

- Accredited degree where curriculum has been agreed with and approved by the professional awarding body. Qualification enables optional 'entry' into profession as member.
- Professional training, including placement activities integrated into program of formal studies, may be at diploma, certificate or honors level. These types of activity may be necessary to enable professional body membership, often as a license to practice e.g. nursing, social work.

Post experience

- Professional updating at degree level. Either technical update, or license-to-practice renewal activities.
- Post degree apprenticeships, studies or 'matching parts'.
- Post first-degree apprenticeships (typical of white collar business professions).
- Post degree certification – an accredited degree in a technical or professional area is followed by a 'matching part' of professional practice in order to gain membership of the profession. This may sometimes incorporate specific additional training or examinations. Typically this is a gateway to 'chartered' status.

Post Graduate studies

- Professionally accredited post-graduates studies where curriculum has been agreed with the professional body. As with the undergraduate accredited courses, such studies/recognition form a recognized pathway to enable (optional) membership.
- Professional accredited (or not) short courses which enable technical updating. In the case of studies which address areas such as health and safety this may also offer certification.
- Various professional bodies operate a tariff system whereby practitioners are required to accumulate units across a specified set of prescribed activities in order to retain chartered status. Activities might incorporate formal study in short courses, participation in professional meetings, conferences etc.
- Companies and large employers may also have an expectation that employees undertake a given number of hours of professional updating per year, although such regimes are typically less prescriptive.

In many subjects, such as medicine, pharmacy and actuarial science, there is a requirement that a given percentage of faculty members teaching professional subjects should be registered members of the relevant professional body in good standing, so that they can speak from experience and provide role models for their students. Compliance with this requirement is typically measured during accreditation processes. In those subjects, such as nursing and pharmacy, where professional training is integrated into the degree, professional practice is typically assessed against a framework of stated competencies.

In computing, accrediting bodies expect to find evidence that professional issues have been studied across the curriculum; there is, however, no requirement to have achieved professional membership before being able to practice. Although evidence of professional membership amongst faculty is often requested and is seen as a strength, professional issues and practice can be taught by faculty members who are not members of the professional association and indeed many not have had personal experience as computing professionals.

Some continuing professional development is included as part of employment in some computing sectors. In specialized computing areas, employers may provide professional development opportunities such as paying for certification examinations relevant to work or reimbursing the costs of higher degrees. In addition, many computing organizations, such as the ACM, IEEE-CS and the BCS, offer free professional development to their members.

3.2 History of professionalism in computing

The earlier curriculum models developed by the ACM incorporated only the attainment of knowledge of topics required for work in the discipline. These early curriculum models did not include significant reference to professionalism, nor to professional values such as honesty, responsibility, or methods of practice. The 1991 modification of the 1968 and 1978 ACM curriculum models was the first by ACM to mention societal and professional ethics issues. That document stated:

> Undergraduates also need to understand the basic cultural, social, legal and ethical issues inherent in the discipline of computing. […] They should also understand their individual roles in this process, as well as appreciate the philosophical questions, technical problems, and aesthetic values that play an important part in the development of the discipline.[…] Future practitioners must be able to anticipate the impact of introducing a given product into a given environment. […] To provide this level of awareness, undergraduate programs should devote explicit curricular time to the study of social and professional issues [36].

A U.S. National Science Foundation (NSF) funded project on professional values brought more attention to the need for instruction in ethical values and responsibility. This multi-year work, entitled the IMPACT CS Project, brought together a large number of people who produced reports about the public consequences of computing. They generated core content and methodology examples in modular form that could be used to integrate ethics and social responsibility into the computer science curriculum [28].

Not only did later curriculum models incorporate this kind of material into their required topical outlines, but the Computer Science Accreditation Board (CSAB), moved toward incorporating those topics into their requirements for program accreditation. When CSAB merged with the Accreditation Body for Engineering and Technology (ABET), their model for accreditation absorbed these requirements, instituting the need to assess these topics. ACM curriculum models for computing-related programs, such as Information Technology, also added such topics, typically under the title "Societal and Ethical Issues".

Professional topics are now typically listed under "Social and Professional Issues" in curriculum documents. In the 2008 ACM curriculum models in CS and in IT they number eleven and nine, respectively. The complete list is as follows: History of Computing; Social Context; Analytical Tools; Professional Ethics; Risks; Security Operations; Intellectual Property; Privacy and Civil Liberties; Computer Crime; Economics of Computing; Philosophical Framework; Professional Communication; Teamwork Concepts and Issues; Organizational Content; and Professional and Ethical Issues and Responsibilities.

3.3 Professionalism in Computing Worldwide

In the spirit of the North American Free Trade Agreement, the ICCP encouraged the use of its credential CCP in Canada as a way of recertification of the Canadian Information Processing Society (CIPS) certification program. Canadian citizens may use the CCP as a means of recertification for the Information Systems Professional (ISP) credential in Canada, and a measure of equivalency allows ISP holders to move easily into the U.S.

The movement toward the establishment of Software Engineering as a Profession arose as a special initiative of the IEEE-Computer

Society. The ACM joined in this effort and worked as a part of the Software Engineering Coordinating Council (SWECC) group toward producing a Software Engineering Body of Knowledge (BOK), as well as a curriculum model and a Software Engineering Code of Ethics. ACM later withdrew, issuing a statement of their opposition to activities that may lead to the licensing of computer personnel as Professional Engineers (PE). Part of this project was initiated by a request from the State of Texas requesting assistance with the creation of a licensing examination for Computer and Software Engineering. Several states in the U.S. had proposed legislation to license computing personnel, and the State of Texas had passed legislation requiring software engineers working in Texas to be licensed as PEs. Soon afterwards the IEEE-CS, which had withdrawn from its membership in ICCP, the certification body, released its own certification examination in Software Engineering, which became the Certified Software Development Professional (CSDP) examination.

Nations around the world began to emphasize aspects of professionalism through their national computing association membership groups. The Australian Computer Society managed accreditation of college programs and offered a certification examination. In Canada, accreditation of college curriculum and certification of workers was being done by the Canadian Information Processing Society (CIPS). In the United Kingdom, the British Computer Society (BCS) had been chartered by the Queen to serve as the leader of the computing movement. The BCS serves the UK to promote the study and practice of computing, to educate, to establish standards for, to advance the study of, to educate the public with respect to computing, to maintain a "registry" of persons classified as members, etc. The BCS is also required to establish and maintain standards of professional competence, and supervise and ensure the ethical practice of information systems practitioners.

The movement to have a worldwide initiative for professionalism was brought to the International Federation for Information Processing (IFIP) by Charles Hughes, President of the BCS. At the IFIP World Computer Conference [41] a Declaration on ICT Professionalism and Competences was approved, and an IFIP sponsored Professional Practice Program had begun. At the date of the working group meeting in 2009, several nations had already received equivalencies approved for IFIP IP3 certification, including the UK, Canada, Australia, and New Zealand.

3.4 Survey Results on Attitudes to Inculcating Professional Values in Computing Degrees

Our surveys tested the hypothesis

H5. There are areas of professional values that teachers are prepared to recognize and inculcate.

using a Likert scale to measure agreement or disagreement with the statements

"**Institutions that teach professional subjects have an obligation to establish strong ethical values in those areas that affect professional conduct**",

"**Faculty should avoid advocating moral and professional standards to students**"),

"**When a discussion is appropriate, I am usually comfortable discussing professional values in my courses**",

"**I/Faculty do not have the right to impose my/their position on students**" (not asked of students), and

"**Some faculty consider it their right to impose their positions on students**". The results are shown in Tables 5 – 9.

Table 5 Obligation to establish strong ethical values in those areas that affect professional conduct (% within type of respondent)

	N	Agree strongly	Agree to some extent	Dis-agree to some extent	Dis-agree strongly
Students	128	23	59	12	6
Faculty	38	63	32	3	3
Profes-sionals	59	46	46	8	0
All	225	36	51	9	4

The data in Table 5 strongly supports H5. It also highlights differences between students on the one hand and faculty and professionals on the other; a Tukey HSD test shows this as significant at the 5% level. It is encouraging that difference is primarily over the degree of agreement, with only a small proportion of the respondents disagreeing at all.

The results in Table 6 also support H5, with a similar proportion of faculty members in favor of advocating moral and professional standards to students. The responses of students and professionals are close and in both cases a significant majority is in favor of such advocacy.

Table 6 "Faculty should avoid advocating moral and professional standards to students." (% within type of respondent)

	N	Agree strongly	Agree to some extent	Dis-agree to some extent	Dis-agree strongly
Students	132	4	23	50	23
Faculty	38	3	16	13	68
Profes-sionals	59	5	20	36	39
All	229	4	21	40	35

It is encouraging that Table 7 shows that students and faculty are in agreement that faculty are comfortable discussing professional values in their courses and that a large majority of professionals feel that this is an important component of the curriculum.

Table 8 shows that 40% of faculty feel that they are entitled to impose their position on students, whereas only a quarter of professionals feel that they should do so.

Table 7 "Attitudes to discussing professional values." (% within type of respondent)

	N	Agree strongly	Agree to some extent	Dis-agree to some extent	Dis-agree strongly
Students	124	29	58	8	5
Faculty	37	57	40	3	0
Profes-sionals	58	53	43	3	0
All	219	40	51	6	3

Faculty members are revealed by Table 9 to be somewhat suspicious of their colleagues approach and it is reassuring that students do not report a high level of pressure to adopt values regardless of their own views.

We also asked respondents to agree, disagree or neither for each of the attitudes and behaviors in Table 1 that "**It is worthwhile inculcating these attitudes/behaviors in students".**

Tables 10 and 11 show the percentages agreeing that it is worthwhile to inculcate each of these proposed professional values from Table 1 in students. As with Tables 3 and 4, this can be interpreted as the strength of consensus that this value is important in the curriculum. We have ranked the responses of each group of respondents according to their strength of consensus with it.

The level of disagreement with inculcating these attitudes and behaviors (excluding loyalty) was consistently very low across all groups. The highest was 8.2% of students and 7.1% of professionals disagreeing that it would be worthwhile to encourage students to anticipate requirements and not wait to be told what to do.

We can see that, on average, faculty and professions are in close agreement that all these values except loyalty should be inculcated as part of a computing degree programme. Students are less sure, but still (just) give majority support to the inclusion of all the values except loyalty. The main difference comes in the inculcation of behaviors, where students are noticeably less keen to be encouraged in good professional behaviors than faculty and professionals are to inculcate these.

Table 8 "I/Faculty do not have the right to impose my/their position on students." (% within type of respondent)

	N	Agree strongly	Agree to some extent	Dis-agree to some extent	Dis-agree strongly
Faculty	38	29	29	34	8
Profes-sionals	56	36	39	21	4
All	94	33	35	27	5

Table 9 "Some faculty consider it their right to impose their position on students." (% within type of respondent)

	N	Agree strongly	Agree to some extent	Dis-agree to some extent	Dis-agree strongly
Students	125	10	33	34	22
Faculty	34	26	44	21	9
Profes-sionals	48	15	56	15	15
All	207	14	40	28	18

On the whole, the ranking of the values is consistent; though it is noticeable that faculty are considerably keener to inculcate meeting the expectations of clients/users than students are to be inculcated with this value. The differences between the means of the groups is statistically significant at the 5% level using a Kruskal-Wallis test for personal commitment to quality, willingness to think like users, taking pride in work, honesty and trustworthiness, openness to critique, reaching out for responsibility, thinking creatively and attending to the needs of users, clients and customers.

The lower levels of agreement amongst students compared to the consensus amongst faculty and professionals suggests that there is strong potential for education in this area to be valuable, particularly to develop actual professional behavior rather than just a belief that one has adopted professional attitudes.

Table 10 "It is worthwhile inculcating these attitudes in students." (% agreeing)

Inculcate attitudes	Students		Faculty		Professionals	
N=231	%	Rank	%	Rank	%	Rank
A personal commitment to quality	78	1	97	1	90	1
Openness to constructive critiques on how to improve	77	2	95	2	86	2
Being willing to put in the extra effort needed to successfully complete necessary tasks	69	3	76	7	77	7
A willingness to attempt to understand and think like the users, customers or consumers of the products they are developing	67	4=	90	3=	84	4=
Taking pride in work	67	4=	90	3=	86	3
Eagerness to meet the expectations of users, clients, customers or bosses	63	6	66	8	79	6
Honesty and trustworthiness	55	7	84	6	75	8
Loyalty to organizations of which one is part	29	8	29	9	40	9

Inculcate attitudes	Students		Faculty		Professionals	
N=231	%	Rank	%	Rank	%	Rank
Willingness to listen to those one works with	NA		87	5	84	4=
Average for all attitudes	72		79		78	
Average excluding loyalty	78		86		83	

Table 11 "It is worthwhile inculcating these behaviors in students." (% agreeing)

Inculcate	Students		Faculty		Professionals	
N=231	%	Rank	%	Rank	%	Rank
Puts in the extra effort needed to successfully complete necessary tasks	70	1	79	2=	80	2=
Anticipates and does not wait to be told what to do	66	2	71	5	73	5=
Thinks creatively	65	3	84	1	80	2=
Listens to the needs of those to whom they provide services	64	4	76	4	82	1
Meets client/user expectations	63	5	79	2=	79	3
Gets involved and goes beyond their assigned job	57	6	66	6	75	4
Reaches out for responsibility	51	7	61	7	73	5=
Average for all behaviors	62		74		78	

4. AN EXAMPLE OF TEACHING AND ASSESSING PROFESSIONAL VALUES

The concerns of teaching professional values center not only on which ones to choose to include but also on how to teach them.

It is important to be attentive to how and from where students gain their professional values. Investigations and experience can lead us to an understanding of where students begin and where they end up. All have acquired values from their cultures, their home backgrounds, their friends, and from other aspects of their environments. In addition, many students work part-time in IT while studying. We cannot be sure that their workplaces will instill recognized computing professional practices in their employees because membership in professional organizations in the field of computing is small relative to the size of the workforce. A large proportion of the workforce has not graduated in computing fields and many practitioners are primarily self-taught.

Because of the diversity of backgrounds with respect to values, it is important to present students with situations that expose them to choices available to each of its stakeholders and their effects, to allow them to view the decision-making options from the various stakeholder perspectives. The situations often require judgments among choices involving conflicts among competing values. Within engineering disciplines and within applied areas of computing, professional ethics may often involve balancing the competing demands of risks, hazards, efficiency, and quality.

Professional ethics requires a combination of knowledge, skill, experience, an ability to recognize what values may be involved, and the skills to work through to a solution [39]. The methodology for evaluating a situation is somewhat similar to that of moving from requirements capture to evaluation of needs, from selection of the best option to the design of a system. Faculty and students in computing, having studied these methodologies already, may welcome them as applied to the evaluation of professional values.

A prerequisite to developing and practicing the techniques and methodologies of professional ethics is the identification of the professional values that underlie the field. These need to be established, to some extent, before the more complex process of listing the trade-offs among decision options can be made. For this paper our research has focused on professional values and the attitudes that students, faculty and professionals have towards their teaching and assessment.

Professional values are acquired in many of the courses from the topical content, and sometimes from a specific course on ethics. In other cases, students have learned some professional values from mentoring situations, from on-the-job training, and from the society as a whole. It is important to have students examine their own values and compare them to expectations in the discipline.

Although faculty have some hesitation about teaching professional values and considerable hesitation about assessing them, there are examples of good pedagogic practice for teaching many of the attitudes and behaviors that are agreed to be important. This section of the paper describes one in the area of integrity, a value linked to both honesty and trustworthiness..

This section uses integrity as an example of a professional attribute that is desirable for students to have developed, but a value which has been seen as having problematic aspects. Integrity is an attribute that is tied to life and cultural experiences that have affected students' habits and attitudes well before they enter into educational contexts. It intersects with the computing programs in areas relating to plagiarism and academic integrity.

The development of attitudes which like integrity comprise the affective domain is fundamentally rather different from the development of skills and technical and theoretical knowledge that computer science faculty deal with. There are various accounts of the stages of development in the affective domain; one well known one is that proposed by Krathwohl [25], which involved the stages of receptivity, response, valuing, incorporation, and ultimately characterization. While this taxonomy is a useful starting point, it may suggests a simple

pattern of development, where progress through these stages is one directional; the developing of values and attitudes is, however, by no means monotonic.

Various methodologies for teaching values have been such as those suggested by, for example, Illingworth [18] who proposed three basic way of approaching professional ethics: pragmatic (starting with the teaching of existing codes and standards, especially those set by regulatory bodies), embedded (taught as part of a larger concept of professional identity), and theoretical (starting with moral theories and exploring real life scenarios).

4.1 Patterns of Development

Integrity may not be consistently expressed. It may be situational, dependent on changeable attitudes toward various institutions and events. It may be determined by relationships and observed general practice of others in various contexts. There may be vulnerability to shock. These considerations lead to the question of sustainability and reliability of a person's expression of integrity. The value may be avoidance of discipline, reward-based, internalized feeling of satisfaction, or structural – conformance to surrounding societal norms. The perception of the value of integrity may be a factor. How closely does an individual identify herself with the object of her integrity, as well as her current stage of development?

These patterns may be unstable and can make evaluation very challenging.

4.2 Methodologies

Students come in to the classroom with some notion of integrity; the issue becomes how best to extend their sense of this value in the context of becoming a computing professional. Traditional classroom presentations of integrity (along with ethics in general) are often through case studies or philosophical studies. A common complaint is that these techniques provide little more than academic exercises that may have little recognized relevance to the students. In addition to lacking ways of personalizing education, there may be a perception of inconsistency between the educational integrity policies and those of industry in terms of scope (who is covered by the policies) and what is covered, allowed, and disallowed by the respective policies.

Moving beyond this dichotomy may be new approaches that align the academic policies to be more like those in industry and research. Immersing the students (and everyone else) in an environment having a comprehensive and rational set of policies that are taught and integrated into the educational milieu may reproduce the way students learned (or were misled) as toddlers. Riedesel [33] proposed formulation of an academic integrity and ethics policy that incorporates responsibilities for virtually everyone involved in the educational, administrative, and research components, along with a reorientation of focus from defining/detecting cheating to a more industry/professional focus of how to document attributions of credit. This is not trivial, though preliminary tests have shown that students can be taught and do respond positively to this approach. There is some burden on the graders in how best to mark work which may contain contributions from multiple sources, but a related challenge confronts managers on a regular basis.

4.3 Evaluation

Despite persistent doubts that professional attitudes and behaviors can be reliably assessed, it is our thesis that many of them indeed can be in an academic environment. Consider the attributes included in the grids of the survey (see the appendix). Many of these attributes also frequently appear on reference forms, presumably because there is an expectation that responses can be made and are useful. During the years that faculty have to get to know students, it is reasonable to expect that many occasions will arise in which the students reveal aspects of themselves in ways we can with some degree of confidence believe to be accurate. These occasions may be in planned settings, but more often are opportunistic. Therefore it may be necessary to go beyond the traditional objective course evaluation methodologies.

As examples, personal commitment to quality may be determined by consistently seeing student work that goes beyond the minimum requirements. Taking pride in work can often be visibly observed in students' faces, as well as through the exemplary works themselves. Loyalty to organizations can be seen in involvement in department and student groups, volunteering, associating, etc. beyond what one may expect of a student who primarily wishes to "pad his resume". A more systematic way of tracking this data may need to be devised.

One obvious way of assessing integrity is by noting the absence of evidence to the contrary. And sometimes there are observable instances of acting with integrity, though to build in such opportunities may be viewed negatively as entrapment.

Looking at this more carefully, consider the feasibility of assessing at the various stages of development of integrity, using the lower three levels of Krathwohl's five level taxonomy. According to Krathwohl [25], the first level is receiving, in which the learner is aware of the topic and willing to learn about it. Traditional techniques of presentation and evaluation certainly should be sufficient.

The second level is responding, which ranges from reluctant compliance up to attainment of a sense of satisfaction for complying. Simple observation, without the need to determine the motivations, may suffice. The main challenge is in finding the opportunities in which integrity becomes a factor.

The third level is valuing, in which the learner ascribes worth to integrity and adopts its practice. Simple testing and observation may not be sufficient to determine the motivation of a student's exercise of integrity, though through extended interactions there may be instances that provide some level of assurance that integrity is ingrained. One thing to recognize is that there may be relapses of both motivation and practice, as life experiences may shake ones ethical system. This is to be contrasted with the acquisition of objective knowledge which may fade over time, but it basically seen to be monotonically increasing, as in the accretion model of learning.

4.4 Implications

Whatever their limitations, sample solutions can guide the assessment of examinations, and rubrics can assist the evaluation of creative works such as programs; but what can be used for affective characteristics such as integrity? How can we ensure a reliability as well as practicality? How can we compensate for the life experiences and biases of the evaluator?

We are, of course, called upon regularly, however, to make such evaluations in the forms of the references we write for students. References in fact seem to carry an implied expectation that these many of the characteristics we have been discussing, particularly integrity, can be evaluated; of course, most students will be very careful with whom they choose to be their evaluators!

Perhaps in practice a more accurate evaluation may be more assured by distributing the responsibility among multiple members of staff, possibly including non-major faculty, internship supervisors, and others who have had opportunity to observe the student. A rating may need to be determined that goes beyond traditional grades of traditional courses.

The effectiveness of the teaching of integrity as well as its evaluation will be dependent on the quality and attitude of markers and others who observe students and their work. An environment of shared responsibility is clearly necessary.

5. ATTITUDES TO ASSESSING PROFESSIONAL VALUES

5.1 Measuring professionalism in the work force

Several years before the release of the 1968 ACM curriculum model in "Computer Science", an early interest in professionalism emerged, coming predominantly from employers. The 1964 conference of the ACM Special Interest Group for Personnel Research (SIGCPR) highlighted information about professionalism. Influential professional bodies such as the Data Processing Management Association (DPMA), which is now the Association for Information Technology Professionals (AITP), were interested in ways to determine the suitability of applicants. At that time only a few college programs existed other than two-year college programs in "Data Processing.

Many employers used entry exams to determine aptitude of applicants. One of the first certification exams became, in 1962, the Certificate in Data Processing (CDP) program initiated by the DPMA. Among aptitude examinations were those developed by corporations, the one by International Business Machines Corporation (IBM) is most notable.

These early efforts in the 1960s to assess workforce aptitude and knowledge led to a movement for professionalism through certification credentialing. In the U.S. the community college system offered Associate Degree programs in Automatic Data Processing, and in the UK the government had an automatic Data Processing aptitude testing program. In the UK, the British Computer Society introduced examinations. Early computer science departments were established in the 1960s at leading universities such as Manchester. In the U.S., university computer science degree programs were started predominantly in the graduate schools, with undergraduate level degree programs coming soon afterward.

Several papers, panel sessions, and op-ed articles on professionalism appeared in publications of the DPMA and the ACM. A panel session headed by the ACM President in the 1971 ACM SIGCPR conference emphasized professionalism in "Information Processing" rather than in "Computing".

The academic disciplines under the umbrella of "computing" or the "computing sciences", or "informatics" began with courses and programs useful for the workplace, but became better defined and delineated as a result of the release of curriculum models developed by the ACM. The disciplines became and continue to become more crystallized through the continuing work of ACM and other groups to develop curriculum models.

The simple, obvious and correct answer to the question 'How are professional values acquired?' is 'In many ways'. For those involved in designing pre-professional curricula, what steps can be taken to ensure that by the time students successfully leave their pre-professional education they have acquired a basic set of values, the perception to recognize the issues that might be involved in their decisions and the judgment to choose between competing considerations and make good choices in the real practical decisions that they will be encountering in their professional activity?

In the original paper from the ITiCSE '99 Working Group on Professionalism, the authors recommended that "Instructors in CIT should infuse 'Professionalism' into the Curriculum" and "develop more effective assessment and evaluation techniques." and suggested some suitable exercises and assessments [26]. The Graduate Attributes Model adopted by the University of Sydney [38] and similar outcomes models elsewhere require programs to develop broad attributes, including professional values, in their students. In the case of the University of Sydney, the mission statement and policies state what outcomes are expected and this is cascaded down into the course level specifics. Discussing this approach, Hall and Bryant conclude that "Assessing students' professional skills relative to common program goals is easier and more accurate with a consistent approach to assessment" and they suggest developing common rubrics and metrics to assess those professional elements across all courses [15].

If we also consider a likely and desirable outcome from the student perspective as graduate-level employment, then we are doing students a disservice if assessment does not also take account of the attributes necessary for that outcome. Both these perspectives are mirrored in comments on the questionnaires, a faculty respondent's comments. "Assessment is a difficult and technical subject. Most in the School of Education would be highly critical of an ad hoc assessment approach. Any assessment approach must itself be 'certified' and this puts more burden on the instructors teaching the course." A management respondent makes the link to recruitment "All of the above attributes are likely to be investigated at the interview stage by quality employers, and any ability to demonstrate the attributes would be an advantage. We are no longer in a business where meeting our own expectations is enough; we have to be customer-centric."

Work experience, projects and other activities modeling the real work experiences are suggested as ways of developing professional values, and have been endorsed by curriculum advisory bodies such as the QAAHE in the UK and the ACM IEEE in the USA. It follows, therefore, that employer approaches to assessment of professional values could provide useful models; many use a competency approach which are defined and broken down to provide a hierarchy of behaviors which have either positive or negative indications. These competencies are typically used not only at entry level but for promotion. Best practice gives graduates a clear explanation of the behaviors which need to be evidenced in application forms or at interview: [17]

5.2 Survey Results on Assessing Professional Values

The surveys tested the hypotheses

H3. Students do not mind being evaluated on their practice of professional values.

H6. There is a consensus that it is appropriate to evaluate students' ethical and professional values.

using a Likert scale to measure agreement or disagreement with the statements **"It is not the job of lecturers to evaluate professional ethics"** and **"I am uncomfortable with academics judging the professional commitments of students".**

The results shown in Table 12 and Figure 2 partially support hypothesis H6, indicating that many professionals but only 43% of students feel that teachers should evaluate the professional ethics of their students, and this difference is significant at the 5% level. It would be interesting to investigate further why a small minority of students are so strongly resistant to this. We also need to analyze the data further to see if senior students are closer to professionals in their responses than beginning students.

Table 12 "It is not the job of lecturers to evaluate professional ethics" (% within type of respondent)

	N	Agree strongly	Agree to some extent	Dis-agree to some extent	Dis-agree strongly
Students	130	12	43	32	13
Faculty	38	3	16	24	58
Profes-sionals	58	2	31	34	33
All	226	8	35	31	26

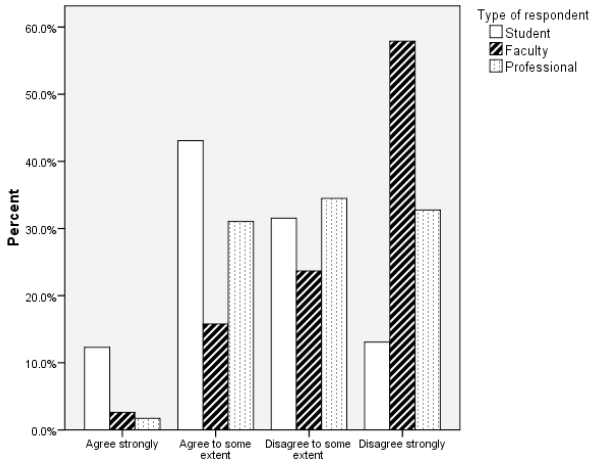

Figure 2 – "It is not the job of faculty to evaluate students' professional ethics"

Table 13 partially supports hypothesis H5. 65% of faculty are comfortable assessing the professional commitments of students and the majority of students are willing to measured in this area. The dissenting group is the professionals, who by a small majority feel uncomfortable with academics assessing professional commitment, a difference that is not statistically significant at the 5% level This may be because they have doubts about the professional experience of faculty and therefore about their ability to make judgments that relate to the professional domain.

Table 13 "I am uncomfortable with academics judging the professional commitments of students" (% within type of respondent)

	N	Agree strongly	Agree to some extent	Dis-agree to some extent	Dis-agree strongly
Students	125	10	31	33	26
Faculty	36	8	28	53	11
Profes-sionals	56	11	45	32	12
All	217	10	34	36	20

Tables 14 and 15 follow the approach of Tables 3 - 4 and 10 – 11, giving the percentages agreeing that it a good idea to determine whether students behave in accordance with each of the proposed professional values in Table 1.

We found levels of disagreement of between 10% and 15% for taking pride in work (students & faculty), honesty and trustworthiness (students), eagerness to meet expectations of users etc (faculty), anticipating requirements (13% across all respondents), reaching out for responsibility (12% across all respondents) and going beyond assigned tasks to get the job done (students and faculty). This disagreement is higher for loyalty (19% across all respondents).

The most striking feature of Tables 14 and 15 is the strength of agreement on commitment to quality, and of willingness to attempt to understand and think like users etc as an attitude and on listening to the needs of those to whom they provide services as behavior. These, plus honesty and trustworthiness, and openness to constructive critiques are the only professional values that a majority of all the groups agrees it is important to detect in students. Overall, a small majority of all types of respondents think that it is important to detect professional attitudes in students. Somewhat surprisingly, a lower proportion of each group thinks it is important to detect professional behaviors in students, with the gap being particularly marked in the students themselves. They could be accused of wanting to be seen to have their hearts in the right place without actually performing in a professional manner.

Noticeable differences are that detecting willingness to put in the extra effort needed to successfully complete necessary tasks is of much higher importance to professionals than faculty and students, students are less keen to be measured on whether they anticipate demands and do not wait to be told what to do, and

faculty place much more emphasis on detecting willingness to listen to those they work with than do either students or professionals. Within each attitude or behavior there are no statistically significant group differences at the 5% level.

Table 14 "It is important, if possible, to determine if a student has such attitudes." (% agreeing)

Determine attitudes	Students		Faculty		Professionals	
N=231	%	Rank	%	Rank	%	Rank
A willingness to attempt to understand and think like the users, customers or consumers of the products they are developing	60.4	1	57.9	3=	63.2	1=
Openness to constructive critiques on how to improve	58	2	58	3=	56	3
A personal commitment to quality	52	3=	63	1	60	2
Eagerness to meet the expectations of users, clients, customers or bosses	52	3=	42	7	54	6
Honesty and trustworthiness	52	3=	58	3=	51	7
Taking pride in work	46	7	50	5	55	4
Being willing to put in the extra effort needed to successfully complete necessary tasks	49	6	45	6	63	1
Loyalty to organizations of which one is part	37	8	34	8	37	8
Willingness to listen to those one works with	NA		61	2	54	5
Average for all attitudes	51		52		55	
Average excluding loyalty	53		54		57	

Table 15 "It is important, if possible, to determine if a student behaves in such a manner." (% agreeing)

Determine values	Students		Faculty		Professionals	
N=231	%	Rank	%	Rank	%	Rank
Meets client/user expectations	49	1	66	1	50	4=
Puts in the extra effort needed to successfully complete necessary tasks	44	2	47	4	52	1=
Thinks creatively	41	3	55	2	52	1=
Gets involved and goes beyond their assigned job	39	4	42	5	50	4=
Anticipates and does not wait to be told what to do	38	5	50	3	52	1=
Reaches out for responsibility	37	6	40	6	41	6
Average for all behaviors	35		43		50	

Tables 16 and 17 give the percentages agreeing that each of the proposed professional values can be workably assessed. This can be interpreted as the strength of consensus that testing this value is important in the program of study. The data is slightly problematic as the question was asked in a positive form to students but in a negative form to professionals and some faculty. Here it is reported throughout as a response to a positive question. Somewhat surprisingly, none of these values gain majority support for their ease of assessment across all groups, not even commitment to quality which is the highest ranked by every group. This is partly because the workable assessment of none of these values commands majority support from students. Professionals are more confident than faculty in assessing attitudes, though their only majority is for assessing commitment to quality, but less confident about the assessment of behaviors. Faculty are more varied in their responses, with majorities supporting the workable assessment of four of the listed values. Unsurprisingly, no group is keen to assess loyalty.

Significant differences are that students are more likely to think that being eager to meet the needs of clients and to get involved and go beyond their assigned job are the most assessable values, whereas a majority of faculty think that they can measure meeting expectations and thinking creatively. The differences between groups are statistically significant at the 5% level for whether it is workable to assess personal commitment to quality, thinking like users, taking pride in work, willingness to put in the effort to complete necessary tasks, and thinking creatively.

Overall these figures support the conclusion that there is considerable support for the assessment of professional values but that we need to win over a number of faculty and, more particularly, students to this point of view.

Table 16 "This is an area which can be workably assessed."

Assess attitudes	Students		Faculty		Professionals	
N=231	Agree %	Disagree %	Agree %	Disagree %	Agree %	Disagree %
A personal commitment to quality	40	25	53	13	54	11
A willingness to attempt to understand and think like the users, customers or consumers of the products they are developing	31	22	53	3	47	9
Taking pride in work	28	27	34	24	46	11
Being willing to put in the extra effort needed to successfully complete necessary tasks	31	22	37	16	47	9
Honesty and trustworthiness	22	35	26	18	32	30
Loyalty to organizations of which one is part	15	34	11	42	26	39
Openness to constructive critiques on how to improve	39	15	40	13	46	7
Willingness to listen to those one works with	NA		37	11	47	9
Eagerness to meet the expectations of users, clients, customers or bosses	34	20	32	21	43	9
Average for all attitudes	30	25	36	18	43	15
Average excluding loyalty	32	24	39	15	45	12

Table 17 "This is an area which can be workably assessed."

Assess behaviors	Students		Faculty		Professionals	
N=231	Agree %	Disagree %	Agree %	Disagree %	Agree %	Disagree %
Anticipates and does not wait to be told what to do	29	18	42	13	38	14
Reaches out for responsibility	23	17	24	18	39	13
Gets involved and goes beyond their assigned job	41	10	34	16	39	16
Meets client/user expectations	44	7	58	8	43	9
Thinks creatively	34	13	53	3	46	7
Listens to the needs of those to whom they provide services	40	8	42	11	48	5
Puts in the extra effort needed to successfully complete necessary tasks	36.6	14	40	5	48	9
Average for behaviors	30	12	49	11	43	10

6. DISCUSSION AND RECOMMENDATIONS

6.1 What Professional Values Should We Include in the Academic Curriculum?

Our work confirms that the professional values identified by the 1999 ITiCSE Working Group are shared and seen as important by computing professionals, faculty and students, with the sole exception of loyalty. We therefore recommend that these should all be inculcated in degree programs in all the computing subjects.

While we have identified some professional values that should be included in a computing curriculum, we did not cast our net very widely in this research. We believe that we have identified a number of characteristics of possible values that when fulfilled should almost as a matter of course be included as learning outcomes.

- These are important for employability.
- These have wide acceptance by computing professionals and academics.
- These can be workably assessed.

There is already a high level of consistency in all groups between identification of attitudes valuable in professional life and values that should be instilled in students. We see this as a move towards another sort of constructive alignment [6]: a constructive alignment of the curriculum with the profession. There remains a significant requirement for the more constructive alignment between assessment and curriculum in development of values:

- Lecturers need to be more aware that they are detecting and assessing professional values all the time.
- There is a discrepancy between support for instilling a value and support for detecting it. This raises the question how can we tell if instilling is working?
- There is a complex relationship between support for detecting and for workableness of assessment, showing both consistencies and discrepancies.
- It is a little puzzling that students and professionals are keener on assessing attitudes than on assessing professional behaviors. One would think that assessing behavior was more straightforward than assessing attitudes. At least faculty are more aware about this.

6.2 Shared and Unshared Values

We observe that shared and core values are not, of course, the whole picture of values in computing. There are areas in computing that illustrate values in conflict. One example of this is how to appropriately implement professionalism. Professionalism itself is a value and one that most computing professionals would assent to. However, the conflict of this value with other values has led the ACM to strongly reject the notion of licensing of computing professionals.

Similar wide-ranging differences are the views on what our field should be called ('computing', 'computer science' …) It is possible that this reflects deep differences in values. Conflicts and differences of value also involve the issues of Intellectual Property Rights (IPR). Anecdotal evidence and personal experience suggests that a number of students and presumably some professionals, despite being adamant about their rights to copy software that involves some form of licensing violations, are equally adamant about their being properly compensated for the programming activities.

6.3 Ways in Which We Can Assess Professional Values in HE

To assess if students have acquired a value, we need ultimately to consider both behavior and attitudes. Do they test code regularly, systematically and efficiently? Great. But eventually we want to know more - whether they test because they know we mark for it, because it is a habit they have acquired or because they know that it is a good programming practice they wish to follow.

For students, assessment defines the curriculum [32]. When we decide that certain values are important to computing, we need to explore ways in which we can get students on board; one of the ways of doing this is to assess them; a useful adjunct to this is to link these values to students goals. Recognition that something, as well as being assessed, is important for future employment may ensure some degree of positive attention on the part of many students. We therefore strongly encourage faculty to overcome their resistance to the explicit measurement of professional values, particularly as our evidence suggests that the level of outright hostility to this from students would be low.

A broad range of good practice in assessing professional values has been developed, Structuring assessments so that process as well as product are recorded, reflected upon and evaluated provides a handle on students' judgments and choices as well as a place to give them some crucial feedback.. Structured and assessed group project work through all stages of the curriculum allows the skills and attitudes needed for group work to be taught early and reinforced. Student reflection on process and product can be encouraged by structuring submitted work to include self-evaluation.

Our survey has identified that there is a set of accepted behaviors which are recognized as important and that a considerable number of professionals and faculty recognize as being assessable. Faculty should focus on devising and providing such assessments in manners which incorporate the provision of appropriate and timely feedback to students. This will help scaffold students understanding from an initial position where they are frequently unaware of the expectations of the computing profession to a position in which they are well on the way to sharing the values which will make them employable in their chosen career.

Future work is needed to devise a bank of suitable assessments addressing behavior in the area of professional values. The computing profession itself has a lot of experience in doing this. It is regularly achieved through appraisal and there is increasing use of competencies to evaluate potential employees. We recommend that faculty investigate how these techniques can be adopted to meet the needs of higher education, bearing in mind that behavior is easier to assess than attitudes but this does not absolve us of the responsibility for assessing attitudes.

One approach to the assessment of professional values could be to use assignments which mimic the workplace setting, such as group projects, and build in a further learning outcomes based on professional values and then use a combination of evidence based peer and personal reflection and assessment to capture student understanding, development and articulation of those values. Students could be given guidance in the process as they would for professional review purposes, and/or in line with the developmental stages as put forward by Krathwohl [25].

7. CONCLUSIONS

We have seen that there is a strong consensus that faculty have a responsibility to impart professional attitudes and establish contexts in which students can practice professional behaviors and learn from that practice.

There is evidence that attitudes and beliefs can and should be judged and educators therefore need to do further work on incorporating those judgments into their normal process of assessment.

Our students need to develop clear ideas of what is involved in becoming a computing professional; they need to form realistic evaluations of how their own professional development is proceeding. Our assessing them is a central element in their coming to evaluate themselves. This is, of course, constructive feedback as an element of formative assessment.

8. ACKNOWLEDGEMENTS

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Appendix A Questionnaire for faculty

(see the end notes for the Students and Professionals questions when those were different)

Attitudes to the assessment of professional values in computing degrees

This survey is part of a wider study of the attitudes of computing professionals, academics and students to the assessment of professional values in Computing degrees. We are interested in whether these groups of people feel that it is acceptable and feasible to assess professional attitudes and values within a degree programme.

We would be grateful for your help through the completion of this anonymous questionnaire. Participation is entirely voluntary.

We will publish a summary of the questionnaire results on the departmental website and it will also be incorporated into research papers for publication. Nothing in publications using the survey results will be attributable to any individual.

Thank you for your assistance

Ursula Fuller and Bob Keim

For the following items please indicate your response:

1. We are scientists and engineers and teach computer science and software engineering. It is not our job to evaluate our students' professional ethics.[i]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

2. Institutions that teach professional subjects have an obligation to establish strong ethical values in those areas that affect professional conduct.[ii]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

3. Faculty should avoid advocating moral and professional standards to students[iii]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

4. When a discussion is appropriate, I am usually comfortable discussing professional values in my courses.[iv]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

5. I don't consider it my right to impose my position on students.[v]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

6. Some faculty consider it their right to impose their positions on students.[vi]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

7. I am uncomfortable with judging the professional commitments of students.[vii]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

8. There is an important shared set of values that underlies the profession of computing.[ii]

Agree strongly	*Agree to some extent*	*Disagree to some extent*	*Disagree strongly*	*Not Applicable*
☐	☐	☐	☐	☐

Please feel free to make any additional comments about any of these above:

Please put a tick (✓) in any boxes you AGREE with. Please put a cross (✗) in boxes you DISAGREE with. Leave blank any that you neither agree or disagree with.

Your judgement / A student's attitudes	It is worthwhile inculcating this attitude in our students[viii]	It is important, if possible, to determine if a student has such attitudes [ix]	This attitude will be of value during one's professional life[x]	This is NOT an area than can workably be assessed.[xi]
A personal commitment to quality				
A willingness to attempt to understand and think like the users, customers or consumers of the products they are developing				
Taking pride in work				
Being willing to put in the extra effort needed to successfully complete necessary tasks				
Honesty and trustworthiness				
Loyalty to organizations of which one is a part				
An openness to constructive critiques on how to improve				
A willingness to listen to those one works with				
An eagerness to meet the expectations of users, clients, customers or bosses (or the surrogates for these in academic settings)				

Please put a tick (✓) in any boxes you AGREE with. Please put a cross (✗) in boxes you DISAGREE with. Leave blank any that you neither agree or disagree with.

In your judgement / A student	It is worthwhile inculcating this behaviour in our students[xii]	It is important to determine if a student behaves in such a manner [ii]	This behaviour will be of value during one's professional life[xiii]	This is NOT an area than can workably be assessed.[xiv]
… Anticipates and does not wait to be told what to do				
… Reaches out for responsibility				
… Gets involved and goes beyond their assigned job				
… Meets client/user expectations				
… Thinks creatively				
… Listens to the needs of those to whom they provide services				
… Puts in the extra effort needed to successfully complete necessary tasks				

Please feel free to make any additional comments about any of these above:

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[i](S) We are studying computer science, information technology and software engineering. It is not the job of lecturers to evaluate our professional ethics. (P) The people who teach computer science and software engineering are scientists and engineers. It is not their job to evaluate students' professional ethics.

[ii](S) and (P) the same as for faculty

[iii](S) (P) Lecturers should avoid advocating moral and professional standards to students

[iv](S) When a discussion is appropriate, I find most lecturers are comfortable discussing professional values in my modules. (P) When a discussion is appropriate, discussion of professional values is an important part of learning to be a computing professional.

[v](S) Some lecturers consider it their right to impose their ethical positions on students. (P) Academics don't have the right to impose their positions on students

[vi](S) and (P) Some academics consider it their right to impose their positions on students.

[vii](S) I am uncomfortable with my professional commitments being judged by lecturers. (P) I am uncomfortable with academics judging the professional commitments of students.

[viii](S) It is worthwhile for courses such as mine to foster this attitude (P)It is worthwhile inculcating this attitude in students

[ix](S) It is a good idea to find out if students behave in accordance with this attitude (P) It is important, if possible, to determine if a student has such attitudes

[x](S) Having this attitude will be of value during my professional life (P) This attitude is of value during one's professional life

[xi](S) Whether someone has this attitude is something than can workably be assessed (P) This is NOT an area than can workably be assessed.

[xii](S) and (P) It is worthwhile inculcating this behaviour in students.

[xiii](S)This behaviour will be of value during one's professional life (P) This behaviour is of value during one's professional life

[xiv](S)Whether someone behaves in such a manner can be workably be assessed (P) This is NOT an area than can workably be assessed.