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Flipped Instruction in Engineering Graphics Courses: Current Landscape and Preliminary Study Results of Instructors' Perceptions

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Introduction

The flipped instructional model, where content is delivered outside of class and class time is used for the application of content, continues to gain popularity in education. Since the model's first use by Wesley Baker[1], development and implementation studies have become more prevalent. An index analysis of more than 12,000 journals and 160,000 conference proceedings was conducted to determine the extent and nature of flipped classroom research. The search terms flipped classroom, flipped instruction, inverted instruction, and inverted classroom were used.

The phenomenon appears to gain traction in 2010. Three scholarly research articles were published in 2010 and papers on the topic continue to be published every year with 137 published articles in 2015 (Figure 1). However, with only 300 total articles, there is a notable dearth in the literature given the focus of the flipped classroom in traditional formal education. When the search is narrowed to engineering education, the number of articles is further reduced to 21. Further narrowing of the search criteria to include engineering graphics yields no results. It is clear that the instructional method is being used; however, there is a lack of study into its efficacy in engineering graphics courses.

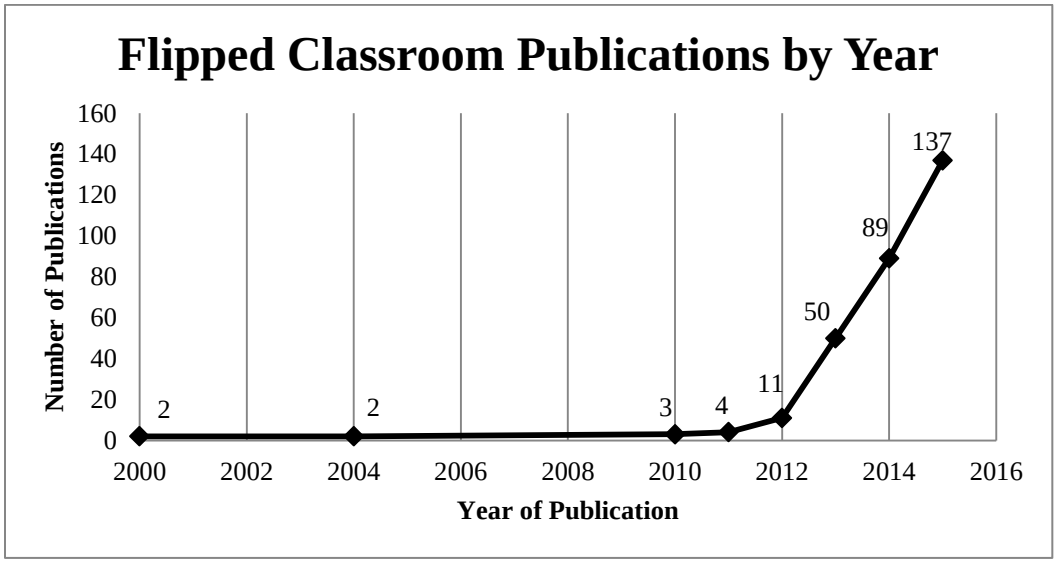

Figure 1. Results of index analysis of flipped classroom literature.

As the flipped classroom expands in usage as an instructional model with the use of information and communications technologies (ICT) and Internet requirements at near ubiquitous levels in the modern post-secondary classroom, understanding the perceptions of instructors within specific domains becomes an important area of study. This research will aid in informing best practices and issues pertaining to the implementation of flipped classrooms and the manner in which this instructional model fits into the engineering graphics education.

This study examines the use of the flipped classroom model in the field of engineering graphics education. This will create a framework from which to conduct further research and inform engineering graphics instructors of how this model is being implemented in other programs.

Methods

An electronic survey was distributed to members of the 2014-2015 Engineering Design Graphics Division (EDGD) of the American Society for Engineering Education (ASEE). This population was selected based on active membership in EDGD, a professional engineering graphics organization. Professional membership was used by the researchers to inform the assumption that the study participants were leaders and experts in the field of engineering graphics education and would be familiar with current instructional trends. The survey consisted of 29 base items collecting demographic information and questions related to their experience with, and understanding of, the flipped classroom model.

Participants

Of the 202 surveys distributed to EDGD members, 57 were completed resulting in a 28% completion rate. Public university faculty represented the majority (93%) of respondents covering all degree levels (Baccalaureate – 93%, Masters – 84.5%, and Doctoral – 34.5%). Instructional areas included engineering (5%), technology (19%), engineering technology (10%), engineering and technology teacher education (32%), design (10%), and education (7%). Building construction management, business, sustainability, and career and technical education are also represented instructional areas in the data set. Tenured or tenure-track professors comprised 89% of the respondents. Thirty percent of respondents report greater than 30 years of teaching experience with all other respondents distributed consistently from 4-30 years of teaching experience. When asked if they have flipped a classroom in the last five years 51% of respondents had. Of those who have not yet used a flipped classroom instructional model 76% stated that they would consider doing so in the future.

Results

Operationalization of the flipped classroom. A seminal and common characterization of the flipped classroom "that events that have traditionally taken place *inside* the classroom now take place *outside* the classroom and vice versa [emphasis original]," [2] was given and respondents asked if they agreed with that definition. Most of the respondents (86%) agreed with the definition given.

Alternatives given by respondents who did not agree with the above definition vary from adding qualifying statements (e.g. adding instructor facilitation) to a re-characterization of the flipped classroom as an instructional strategy rather than a "classroom". The dissenting views offer insight into the perception of the flipped classroom and identify some common criticisms of the phenomenon. Student engagement and facilitation of instruction are common additions to the definition. This facilitation is described in terms of both instructor-student and student-student interactions.

Other definitions given discuss practical applications or project work being part of the in-person component of instruction (Figure 2). Two brought the appropriateness of the definition describing it as an instructional strategy and "not a classroom at all," and that it assumes traditional instruction is lecture-based. The latter also pointed out "many technical fields have included applications in their 'traditional' classrooms for years."

- Engaging students in classroom activities, beyond the scheduled meeting times for the actual class.
- Students do research or work outside the classroom that prepares them for some kind of practical application in-class of what they have learned from their required activities outside of the classroom.
- Things that have traditionally taken place in a classroom that now take outside of the classroom, while students direct the learning and the instructor facilitates that learning.
- The role of professor and students flip with students also teaching other students, inside and outside the classroom
- A flipped classroom is not a classroom at all, but an instructional strategy characterized by most of the initial delivery of instructional content occurring outside of a physical classroom and group setting, and most of the physical classroom time spent in student project work, guided by an instructor.
- The problem with the definition is that it assumes that everyone used to lecture. People in many technical fields have included applications in their "traditional" classrooms for years.

Figure 2. Respondents' alternative definitions of the flipped classroom.

Appropriateness of flipped instruction. There is general agreement among respondents that the flipped classroom model is best suited for upper-level undergraduate (92%) and masters students (90%). However, a majority (56%) maintain the viewpoint that it is appropriate at all levels given including K-12. With only five respondents reporting experience with the model in primary and/or secondary education and the broad range of instructional and developmental differences in the population, the appropriateness of flipped instruction in all levels of K-12 education is beyond the scope of this research.

Not all respondents view the flipped classroom as being appropriate for all students. An analysis of the responses revealed several reasons the flipped classroom may not be an effective strategy. Student level and abilities represented the most prominent issue. This related to the age (grade level) of the student and any disabilities students may have that would impact their capacity to participate fully or meaningfully in the flipped classroom environment.

Student maturity and motivation is also a consistent topic in the responses regarding appropriateness for all learners. Some of the concern was specifically directed at middle and high school students. However, others were more general and were related to students having the self-discipline to properly engage with the out-of-class work. This is addressed by many who responded yes, but qualified their response by stating that proper planning and supports should be in place for the flipped classroom model to be effective.

The preference of students was stated several times as an area where there may be issues in implementing the flipped classroom. Respondents also addressed equity with respect to students having the needed resources at home to participate fully in the class.

Finally, not all respondents felt all courses were appropriate for the flipped classroom model. Some of the concern regarded the course content while others addressed issues such as

distance education. Regardless of the stated concerns, 41% of respondents stated that the flipped classroom is appropriate for all students with most of responses qualified to include that proper planning and structure was required.

Content delivery. The majority of respondents (89%) use learning management software (LMS) to deliver content outside of class. This software category includes Moodle, Blackboard, Edmodo, Canvas, or similar programs. Many (34%) respondents reported using video streaming sites such as YouTube. Portable media (flash drives and CDs) are used by 15% of respondents. Google Docs, wikis, web pages, other streaming video/audio, podcasts, and mobile apps were also reported as being used by respondents.

The majority of the respondents (81%) report being comfortable with the technology (knowledge, skills, and attitude) needed to flip the classroom. However, 19% of respondents being uncomfortable with the technology requirements needs represent a substantial portion of the participants. The issues these respondents described related to time to prepare, lack of experience, doubts of student fidelity, and needing to keep up with modern technology trends.

Reasons for flipping the classroom. The reasons given for flipping the classroom vary greatly and most respondents have multiple motivations for using the flipped classroom model (Figure 3). For instance, the largest category, student engagement, represents 27% of the variance in motivation for flipping the classroom, but 90% of respondents reported it was a factor in their decision.

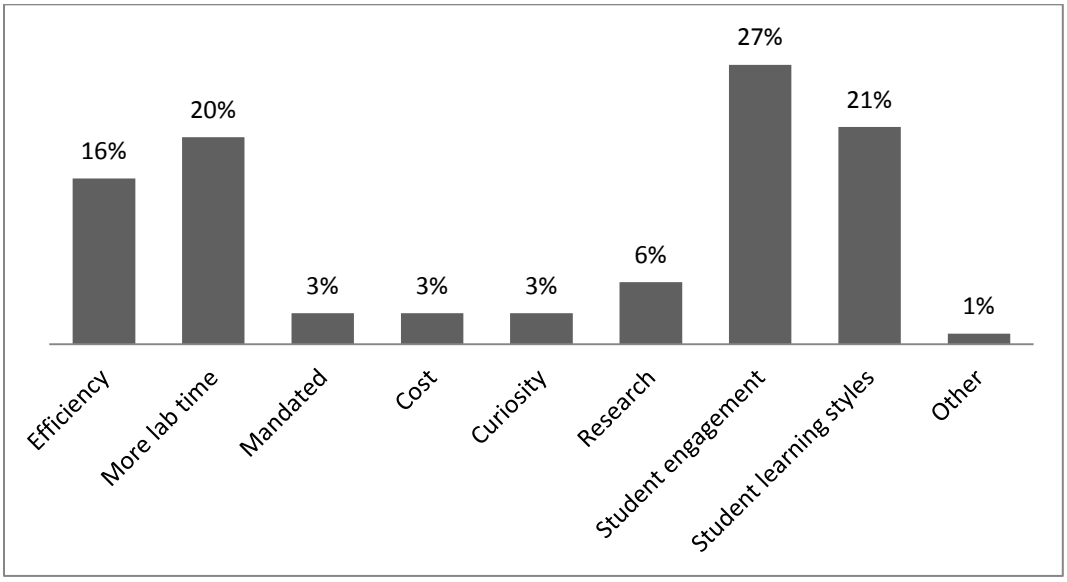

Figure 3. Motivations for using the flipped classroom instructional model.

Other motivations to flip the classroom included student independence, reduced reliance on textbooks, and the development of an asynchronous distance education course.

Accountability. Participants were asked what types of accountability measures they used to ensure student fidelity and engagement with the material requiring out-of-class use. A plurality of respondents used the LMS to track students' participation and engagement with the

resources. This includes metrics regarding whether the material was accessed and how much time was spent interacting with it.

Respondents reported also giving regular formative assessments and assignments. These assignments are due prior to class, leaving class time for expanding on the content delivered outside of class and not reiterating what should have been received prior to class. Assessments prior to class based on the online content are also used.

For some, accountability is mainly in performance evaluation under the assumption that successful project performance requires the use of external resources. Other respondents align their assignments so that their successful completion requires the use of out-of-class resources. The use of student portfolios or requiring student self-evaluation is also used to motivate participation with external content.

Benefits. The greatest reported benefit of the flipped classroom is that respondents have more class time to apply knowledge learned, engage in deeper and richer discussions, and allow for hands-on expansion of learning. This combined with a sense of greater efficiency made time the primary benefit of flipped instruction. This greater efficiency also allows for some respondents to increase course enrollment and service more students. An increase in time also allows for more collaborative and higher levels learning among students.

Student engagement is another common theme among respondents. Several respondents reported responsibility for ones' own learning as a benefit. Students coming to class better prepared and being able to meet the individual learning styles of students are also noted by participants using the flipped classroom model. The phrase "individual learning styles" was used in the survey, as it is commonly used nomenclature. However, the authors note that there is no conclusive evidence that there are, in fact, learning styles as opposed to preferences.[3]

Disadvantages. The reported benefits appear to be very similar to the disadvantages when flipping the classroom. The greatest similar theme is time. Respondents reported the increased planning time required to create content and manage the LMS more than all other topics combined. There are also several responses that indicate greater time spent by students outside of class as an issue.

Unprepared students coming to class were reported by several respondents. Some stated this was due to a lack of participation with the online content or a lack of understanding of the material. A lack of understanding the expectations by students of the requirements of a flipped classroom was also reported. This may coincide with an apparent shift in student expectations. Many students may be accustomed to a cycle of didactic instruction while taking notes with some reinforcing homework or paper to complete after class. The student and instructor are initially outside their familiar approaches. Reduced student interaction in the online environment was also reported.

Technology issues are a common problem in the 21st century classroom. A flipped classroom environment is no different. Students having issues accessing material and resources online is reported as a concern in flipped classroom. Students with technological issues outside

of class (either real or fabricated) were also reported as a disadvantage as they may not come to class prepared.

Discussion

Most of the respondents agreed with the definition of the flipped classroom provided to them. The definitions of those who did not agree and a reading of the responses to the questions regarding benefits, disadvantages, and accountability measures seem to indicate substantive differences in the application and use of the flipped classroom model. These offer reasons for better operationalization of the flipped classroom, a comprehensive taxonomy of the concept, and a more encompassing nomenclature for the flipped instructional model.

There are clear concerns among the respondents with respect to the equitability of the flipped classroom for students with limited access to technology and Internet resources outside of the school environment. This concern is reported in K-12 education and should be addressed in post-secondary education contexts as well. This may apply to more domains than just the course being flipped and may represent a larger equitability issue for low-income students.

Most respondents agreed that the flipped model was appropriate for most students, but there may be issues with students with distinct learning needs. However, leveraging technologies presents an opportunity to address learner demands uniquely. This need should be addressed in the planning stages on a flipped course, but one that best practices may need to be developed and communicated for special needs students. Ultimately, it may fall on the instructor to determine the suitability of the course for those students and adapt it as needed, as in traditional instruction.

Not all content may be appropriate for the flipped classroom. Although respondents did not detail specific content, like any instructional method, professional judgement should be used when determining if a course or parts of a course are appropriate for this method. The comfort of instructors also plays a role in the successful implementation of any new model of instruction.

For these reasons, robust planning and adherence to suitable instructional design principles are needed. It may not be appropriate to just take current courses and put the lecture content online. A greater effort in designing the course to fit the needs of both curriculum and student within the framework of available resources may be needed.

The time and effort required to implement this instructional model properly is mentioned as a disadvantage. However, there is evidence that there are efficiency gains later in the course. There is also a clear need to establish student expectations early in the flipped classroom. Instructional methods may place the student and instructor outside of their comfort zones and prior planning may alleviate, or at least mitigate, potential frustrations later.

There are many references by respondents on the need for student accountability measures to be part of the flipped classroom design. Students and faculty are used to that model of instruction and there is evidence that a more behaviorist approach to the online content is a component of the flipped classroom model.[4] More research and development of the flipped classroom model is needed to determine the most effective methods and theoretical framework(s)

from which to best design and implement the flipped classroom instructional model in higher education.

Conclusion

It is clear that the flipped classroom instructional model is being used in engineering graphics education at the university level. The extent of its use and how the model is operationalized across the field is not clear. This study was designed to understand the landscape of the flipped classroom phenomenon and the perceptions of its use from the perspective of engineering graphics faculty. The majority of respondents in this study accept the characterization of the flipped classroom as defined by Lage, Platt, and Treglia,[2] but it is apparent from the responses and extant literature that no one true model exists.

Comparison of the model from other domains and controlled studies into the effect of the flipped classroom on student outcomes is an essential component of the validity of the model. These studies are generally lacking in the literature and non-existent in engineering graphics education. Given this lack of study of the flipped classroom model, greater attention paid to the engineering graphics content best suited to engineering graphics would only serve to increase the model's efficacy. Detailed statistical analysis of the results of the data in this research may offer greater insight into the relationships between the factors discussed in the preliminary findings of this paper.

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