Abstract: Just-In-Time (JIT), one of the key management concepts in Toyota Production System has been widely discussed as a successful operations management methodology. JIT is based on notions such as minimising in-process inventory, flexibility with customer demands, forced problem solving, empowering employees and consolidating supplier relationship. While exact replica of production system JIT arrangements might not be matching in education systems, some elements and concepts should be beneficially translated/adapted. For example, targeting JIT based enhancements to assessment related feedbacks in education systems is valuable. Therefore, a pilot research by the authors aims to explore suitability by extrapolating interesting lessons and experiences derived from manufacturing supply chains and production management. In this paper, we provide scholarly discussions of our hypothesis that the use of JIT in education systems would be particularly beneficial for improving feedback process and students satisfaction in engineering higher education.

Introduction

In general, student performance in higher education is based on various elements of teaching quality including assessment strategies and feedback practices. Basically, detailed feedback to students shall fine-tune and enhance their learning. Regardless of the diverse assessment strategies used in higher education, ensuring prompt informative feedback is a key requirement for: successful anchoring of outcomes, enhancing learners’ awareness of assessment requirements, and encouraging constructive changes in future performance (e.g. Brown, Bull and Pendlebury, 1997). The principles of good feedback practice outlined by Nicol and Dick (2006) indicated that feedback should: clarify what is good performance in assessments (i.e. goals, criteria, and expected standards), facilitate the development of self-assessment in learning (i.e. reflection); and provide information to teachers that can be used to help shape teaching (i.e. ‘feed-forward’).

Mainly, providing timely feedback to students is advantageous and constructive in higher education (Higgins, Hartley and Skelton, 2001), e.g. constructivist theory based potential ‘deep learning’ opportunities for conscientious learning communities (Higgins, Hartley and Skelton, 2002). Moreover, feedback should be right and relevant for positive impacts as inadequate or improper feedback might be harming/waste. Weaver (2006) reported some such unhelpful feedback, which include: (a) too general or vague, (b) lacked guidance, (c) focused on the negative, or (d) were unrelated to assessment criteria. On the other hand, Carless (2006) suggested that good feedback based on sound fundamentals of discourse, power and emotion will eventually mitigate problems such as mistrust and misconceptions among students.
Despite the significance of feedback in higher education, several critical issues in this crucial domain have not been extensively researched (Mutch, 2003; Carless, 2006; Weaver, 2006). Drawing motivation from such observations, the authors have initiated a pilot research to potentially apply Just-In-Time philosophy for improving the feedback arrangements in selected engineering teaching units. This research will mainly target (a) to develop a systematic classification framework for feedback in different units, (b) to find causal relationships between feedback and student satisfaction, and (c) to develop useful frameworks and guidelines from successful operations management practices especially for improved feedback by applying JIT philosophy. Accordingly, (a) the principal concerns of feedback in higher education and (b) key conceptual discussions of applying JIT and operational management strategies for enhanced feedback are discussed in this paper.

**Brief overview of JIT success in manufacturing and production systems**

The basic philosophy of JIT is regarding organised set of activities leading to lower costs and higher quality in products or services (Canel, Rosen, and Anderson, 2000). In production and manufacturing systems, one way that a manufacturer aims to minimise costs and maximise production is to benefit from scale economies, i.e. large scale production often tend to minimise direct and indirect costs. However, such larger scale productions are challenging as requirement for higher degree of standardisation, larger production cycle time(s), substantial volume/bulk orders, larger inventory spaces and so on. Another concept that supports a larger volume of production is known as Just-in-Case. Based on this concept, we need to produce more to cope with fluctuations in demand and also to deal with faulty products. Therefore, if demand for a product is fairly stable and the specifications of a product do not change through out the time, a larger production is justified. This particularly is the case when products can be inventoried without additional costs (no deterioration cost, no opportunity cost, no warehousing cost, etc.). In some cases, demand for a product is not known in advance and the customer tastes and requirements are also volatile. Then indeed, the economy of scale is not relevant in such cases.

It might be controversial to claim what exactly constitutes the principles of JIT. Earlier researchers (e.g. Mehra and Inman, 1992; Sakakibara, Flynn, and Schroeder, 1993; Spencer and Guide, 1995) have attempted to consolidate specific core principles of JIT. For example, Mehra and Inman (1992) suggested four principles: management commitment, JIT production strategy, JIT vendor strategy and JIT training and education strategy. Accordingly, the management commitment is to provide support, authority and freedom to deal with problems as they occur. For instance, in the Toyota production line, a worker has the authority to stop a production line if he comes across a notable issue. The JIT production emphasises on smaller batch sizes to be produced, unproductive parts of work tasks should be reduced. Activities considered include: (a) minimising setup time, (b) work simplifications that make the process more productive. The JIT vendor strategy is related to working with suppliers to integrate quality improvement initiative and also to better coordinate production activities. The JIT training and education strategy is how to build teams and motivate employees towards the implementation of JIT. Thus, the JIT philosophy is to satisfy customers’ level of demand and type of their demand of faultless products as promptly as possible through identifying hurdles in process. While the idea looks simple, its application requires challenging of many standard accepted concepts in production activities.

Just-In-Sequence (JIS) is an advanced development of JIT philosophy, specifically suitable for production/manufacturing systems in which the sequence arrangements can be well defined and planned ahead of time with enough certainty to enable systematic JIS sequencing (Werner, Kellner, Schenk, and Weigher, 2003). The JIT offshoot of JIS shall include: (a) *pick-to-sequence* in which the production items are systematically ‘picked’ from buffers, sequenced, and delivered to relevant targets in production supply chains (i.e. for reduced buffers in production supply chains and improve ‘work-in-progress’ and cycle times); (b) *receive-to-sequence* in which the production items are internally/externally sequenced at the supplier, delivered in relevant production supply chain sequence, and to
the production (i.e. for reduced inventories and costs); (c) build-to-sequence in which the production items are built according to the production sequence required by the customers or downstream stakeholders (i.e. for reduced inventories and costs).

Do we need JIT in our education systems?

Although there are some notable differences between a commodity production and an education system, some interesting insights from JIT can be used and evaluated in an educational context.

- **First, customer driven feedback:** JIT as a customer driven system has several useful tools which facilitate to integrate a system towards satisfying customer demands and changes. Like many other sectors, customer driven focus/ targets are common in education systems as well. Now, the students have far more choices to choose among universities, courses/ programs, subjects/ units of study in their ambitions for higher education (e.g. undergraduate or postgraduate degrees in engineering and management). One important influencing criterion for students’ choice selection is regarding employment prospects (or immediate career advancement) that such higher education qualifications can bring immediately.

- **Second, operational level feedback:** JIT provides an effective way to establish feedback process in a system. The amount and characteristics of a final product is communicated to immediate previous stages particularly if any issues have been encountered. These communications and interactions continue to the early stages of a production and force employees to highlight and communicate and eventually solve by means of forced problem solving.

- **Third, managerial level feedback:** JIT is an integrative approach, which looks after relationships with suppliers and immediate beneficiaries and also benchmarking with similar type organisations. In production systems and manufacturing supply chains, the quality processing of each stage directly or indirectly influence the quality outcomes in its immediate following stages as well. Similarly, in education system, it would be hard to manage the learning outcomes of a unit (subject) effectively, if students do not have solid foundations on perquisite concepts in their prior studies. The collaboration of teaching teams to join forces on finding solutions for learning communities. The authors perceive that the ‘technology transfer’ of JIT success in production and manufacturing has some potential arrangements for education in the form of useful tools and techniques that were successful in operations management.

**Just-in-Time-Teaching (JITT) in education**

Novak, Patterson, Gavrin, and Christian (1999) discussed Just-in-Time-Teaching (JiTT) and explained the JiTT pedagogy. This JiTT approach is mainly based on a pre-class activity in which the students attempt to answer/ solve a carefully structured exercise. This exercise is based on teaching material that has not been covered yet but students are responsible to explore the problem. Just few hours prior to the lecture, the student can submit their attempts to the concerned lecturer. Based on such submissions, the lecturer plans his lectures ‘just-in-time’. The premise is that students’ submissions provide vital information on their thinking process thereby facilitating more efficient engagement and learning. Web based communication systems are critical requirement to this approach (Garvin, 2006). Simkins and Maier (2004) implemented JiTT in teaching some introductory economics courses in higher education and observed some beneficial improvements in student preparedness before class and positive ‘feedback – feed-forward’ loop from students’ contributions. Also, JiTT enhanced students’ cognitive learning while enables the instructor to understand students’ thinking process. Similarly, Prince and Felder (2006) discussed a comparable JiTT framework for inductive teaching and learning methods, as opposed to traditional deductive teaching methods. They classified inductive teaching method into inquiry learning, problem-based learning, project-based learning, case-based teaching and just-in-time teaching. Moreover, Prince and Feder (2006) conclusions refer: “…while the strength of evidence varies from one method to another, inductive methods are consistently found to be at least equal to, and in general more effective than, traditional deductive methods for achieving a broad
range of learning outcomes...”. Peer Instruction (PI) is another comparable method in which, the students are given the task of reading teaching material before lecture (Mazur, 1997). In most cases of PI based lectures, the students are required to answer some multiple choice questions in groups and they may have to convince their peers regarding their answers. In this process, the student responses are instantly communicated through clickers integrated to a central computer system that processes their answers to resultant statistical information. Based on such information, the lecturer can provide further feedback to guide students so that eventually all students can understand well and verify the answers.

**JIT opportunities for dynamic feedback**

The teacher feedback on students’ performance (i.e. assessment of student works) is required for: (a) coursework submissions by students (e.g. assignments), (b) group projects (including presentations and reports), and (c) tests and examinations. Figure 1 portrays a conceptual overview of JIT opportunities for dynamic feedback in higher education systems.

![Figure 1: JIT opportunities for dynamic feedback in higher education systems](image)

The assessment feedback for student performance can be either feedback from teachers or peer-assessment feedback by students. Also, the feedback of student performance include: (a) coursework feedback, (b) team-work based group project feedback, and (c) test/ examination feedback. In general, the coursework feedback aims to cover specific continuous assessments during academic terms. The JIT/ JIS feedback agenda for such coursework feedback (including assignments and interim tests) could include: (a) immediate feed-forward improvements on student performance within particular academic term, as well as (b) subsequent carry-forward feed-forward knowledge gains for potential future improvements in subsequent similar opportunities (e.g. in next semesters, another subject). In final examinations, the student performance is normally consolidated in a numeric scale (e.g. 0 to 100) or equivalent grades (e.g. High Distinction, Distinction, Credit, Pass, Fail). Depending on the subject requirements and lecturer preferences, the examination paper may include different types of questions such as numeric problems/ descriptive answering type, multiple choices, and true/false type. Within the stipulated short duration (e.g. 2-hour or 3-hour examination) it would be hard to examine learning...
outcomes of all major concepts taught in the academic term and the lecturer may be somewhat selective/ restrictive in designing the examination questions. In most cases, post-examination feedback is non-existent or inadequate. If a student wants to improve and deal with his/her shortcomings (e.g. carry-forward type feed-forward improvements in subsequent stages), the prevailing arrangements are not adequate in such cases. Hence, the JIT/ JIS framework of improved feedback arrangements in higher education is proposed by the authors and related research is ongoing, mainly for developing specific prototype tools, techniques and pilot protocols.

Of course, inherent problems associated with comprehensive feedback (i.e. both coursework and final examinations) have not been overlooked in this research. Yet, the essence of JIT philosophy is expected to provide useful guidance and improved ways of methodically enhancing feedback arrangements in higher education. Some example include: (a) understanding competencies for intended learning outcomes; (b) linking learning outcomes to teaching materials; (c) linking learning outcomes to assessment strategies, e.g. small but frequent assessments; (d) aiming for appropriate group sizes of students for better outcome measurement; (e) letting students to be able to trace their competencies.

**Conclusions**

Dynamic and right feedback of course works and examinations will be useful in higher education. By such arrangements, the students shall better bridge the gap between anticipated and actual performances thereby improving their learning outcomes as well as satisfaction levels. Initial observations in this research indicate that feedback is preferred before finalization of marks or grades. Basically, JIT as an integrative system will provide valuable concepts aiding teaching and learning communities through enhanced feedback arrangements. Requirements of feedback should be systematically identified to invoke a dynamic JIT mechanism in the education system and target further continuous improvements. Already evidences of success from some form of JIT implementation in education has been identified, yet such targets are limited. We argue that the JIT/ JIS applications should specifically focus for feedback enhancements by means of suitable systematic approach to improve the effectiveness and efficiency of teaching and learning in higher education.
References


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